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(52) UK CL (Edition S)

H4P PAQ PDCSL

(56) Documents Cited

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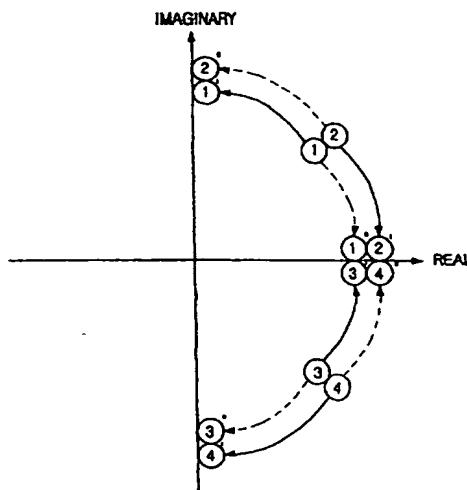
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(54) Abstract Title

Orthogonal modulation scheme with reduced peak to average power ratio (PAPR)

(57) The present invention relates to an apparatus and method for modulating data by employing orthogonal variable spreading factor (OVSF) codes in a mobile communication system. A code generating means generates at least one spreading code to be allocated to a channel and is selected such that two consecutive pairs of in-phase (I) and quadrature (Q) data correspond to two points located on the same point in the phase domain (see figure) or are symmetrical with respect to the zero point (see fig. 9). Data for transmission is then spread using the generated code and phase rotated by a Walsh rotator such that the phase difference between consecutive points is ninety degrees (90°). The ninety degree phase difference leads to a reduction in the peak to average power ratio (PAPR) of a mobile station. Preferably the orthogonal complex quadrature phase shift keying (OCQPSK) modulation scheme is adopted.

FIG. 8



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG. 1

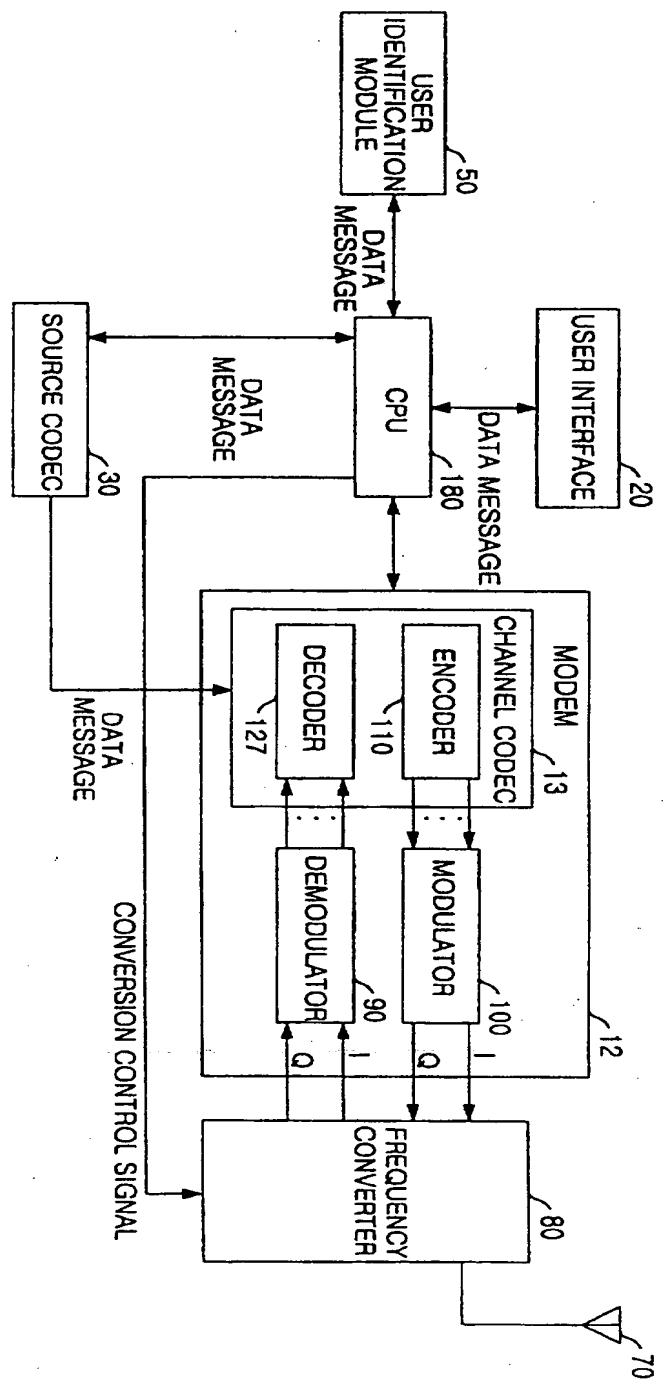


FIG. 2

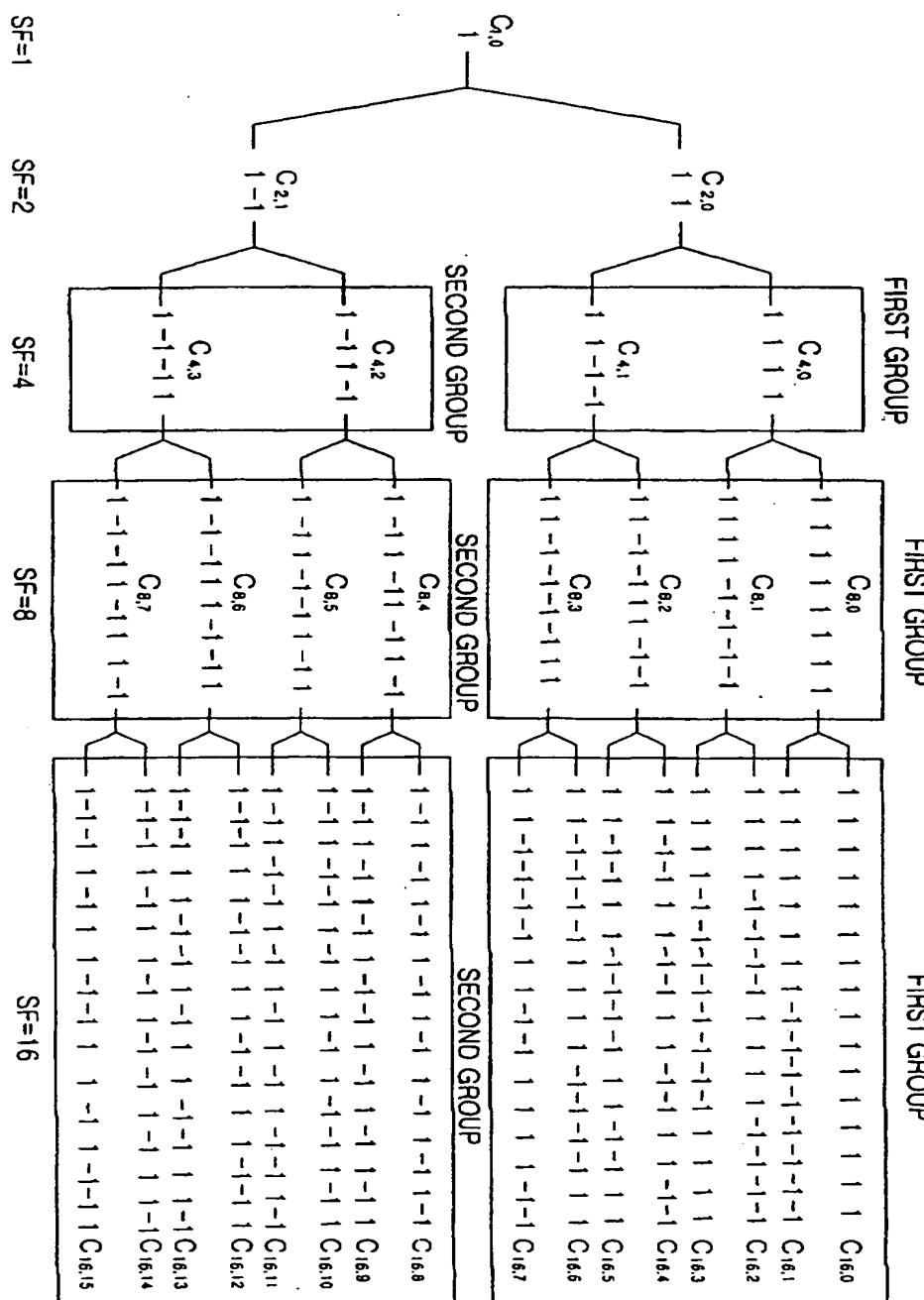


FIG. 3

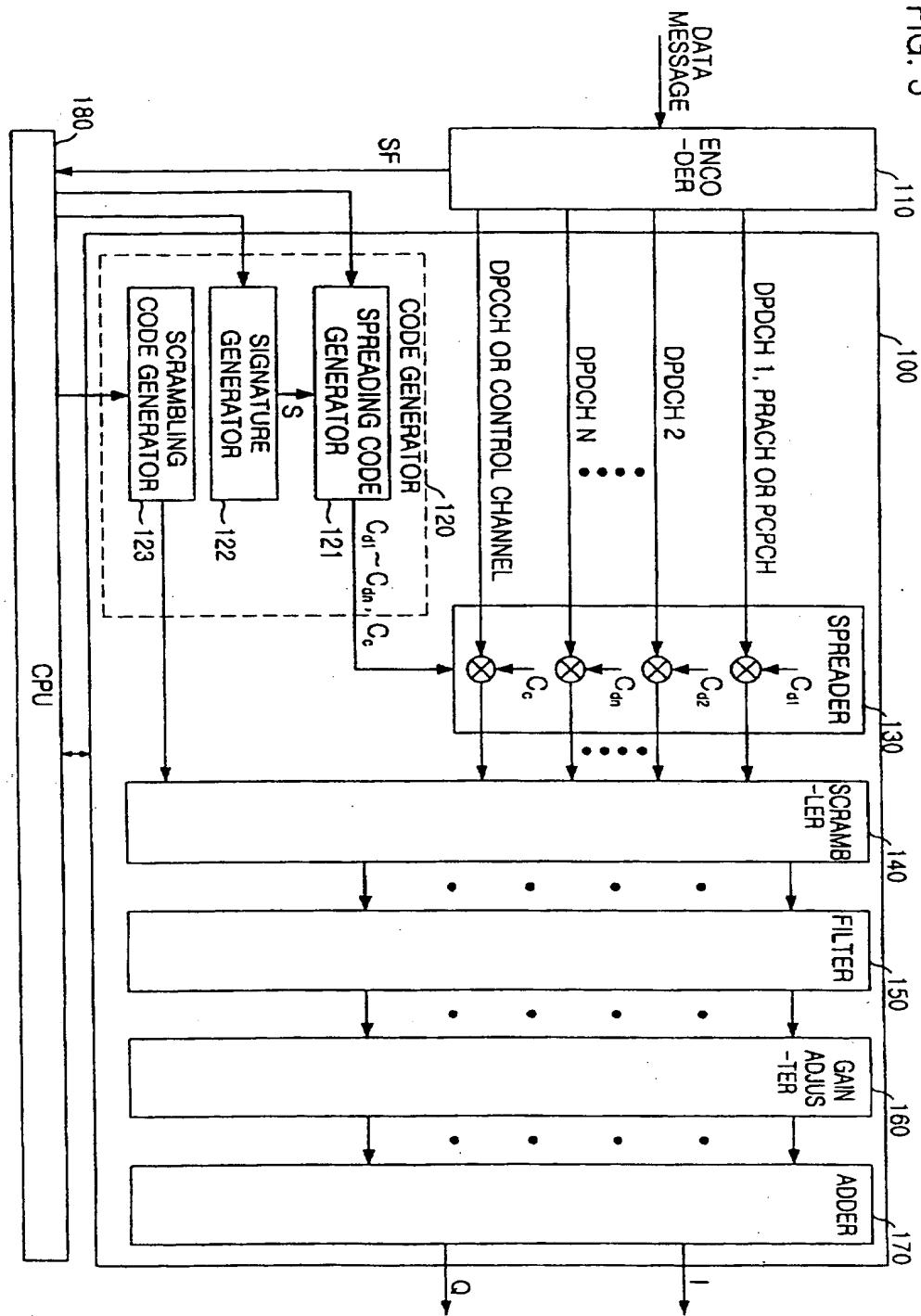


FIG. 4

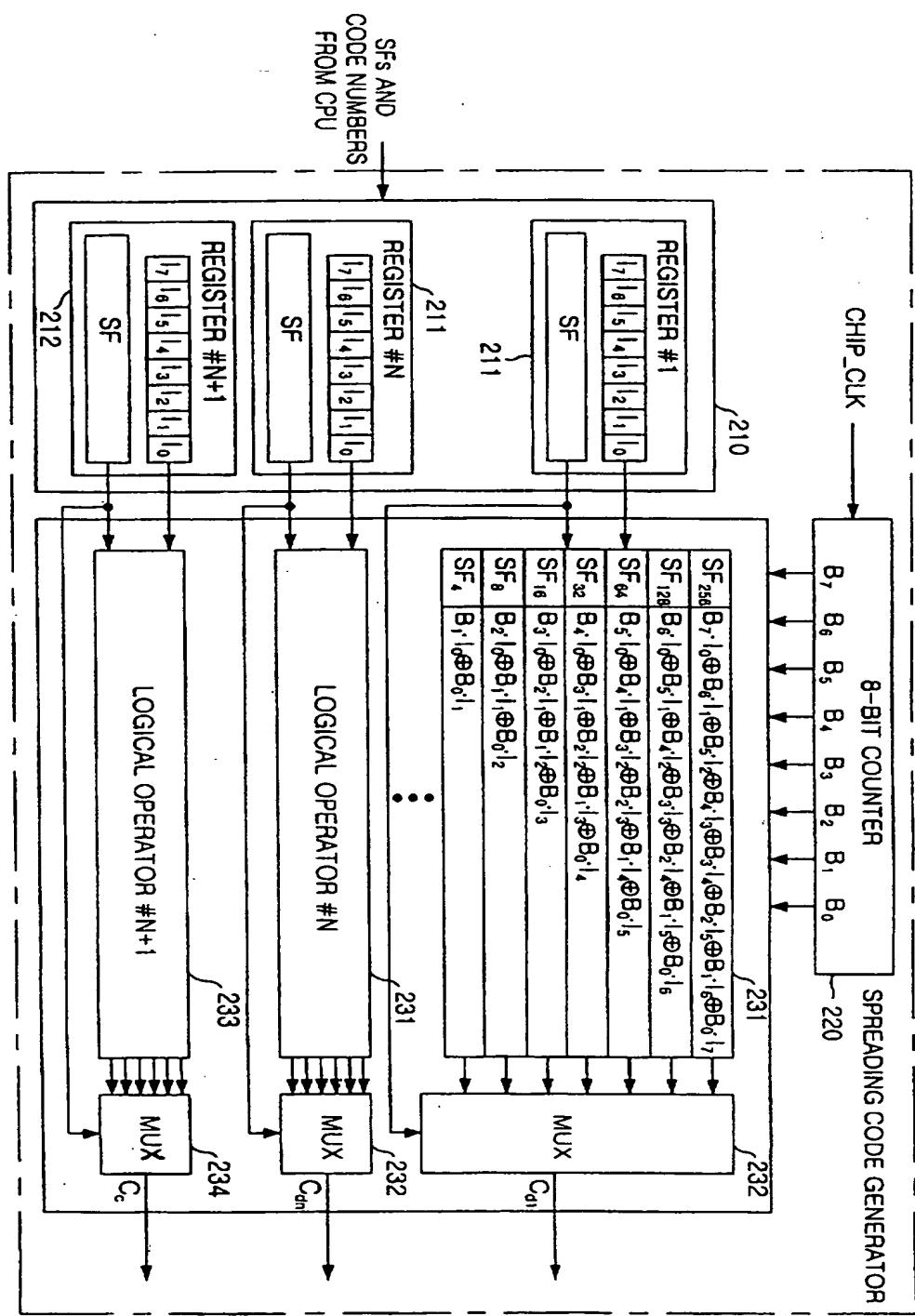


FIG. 5

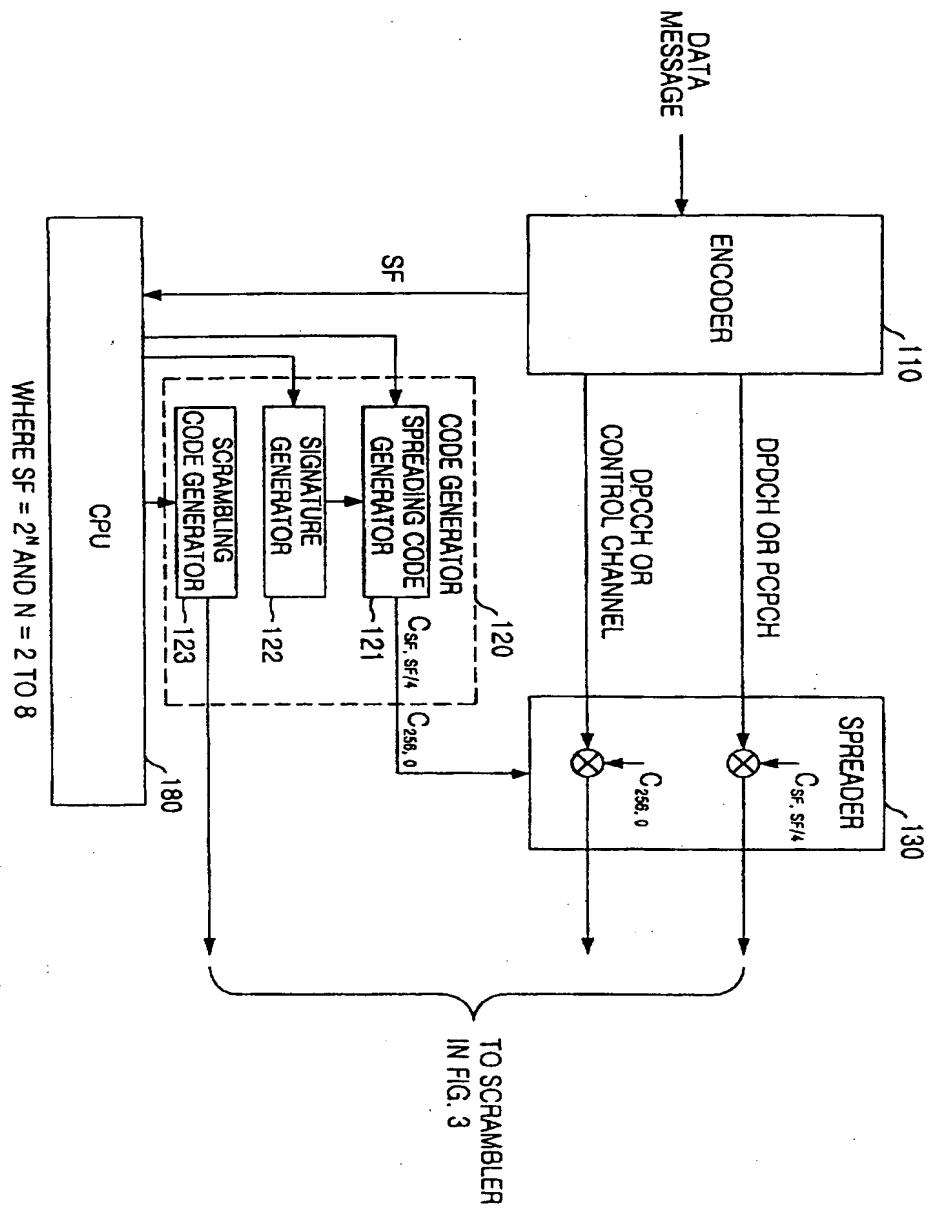
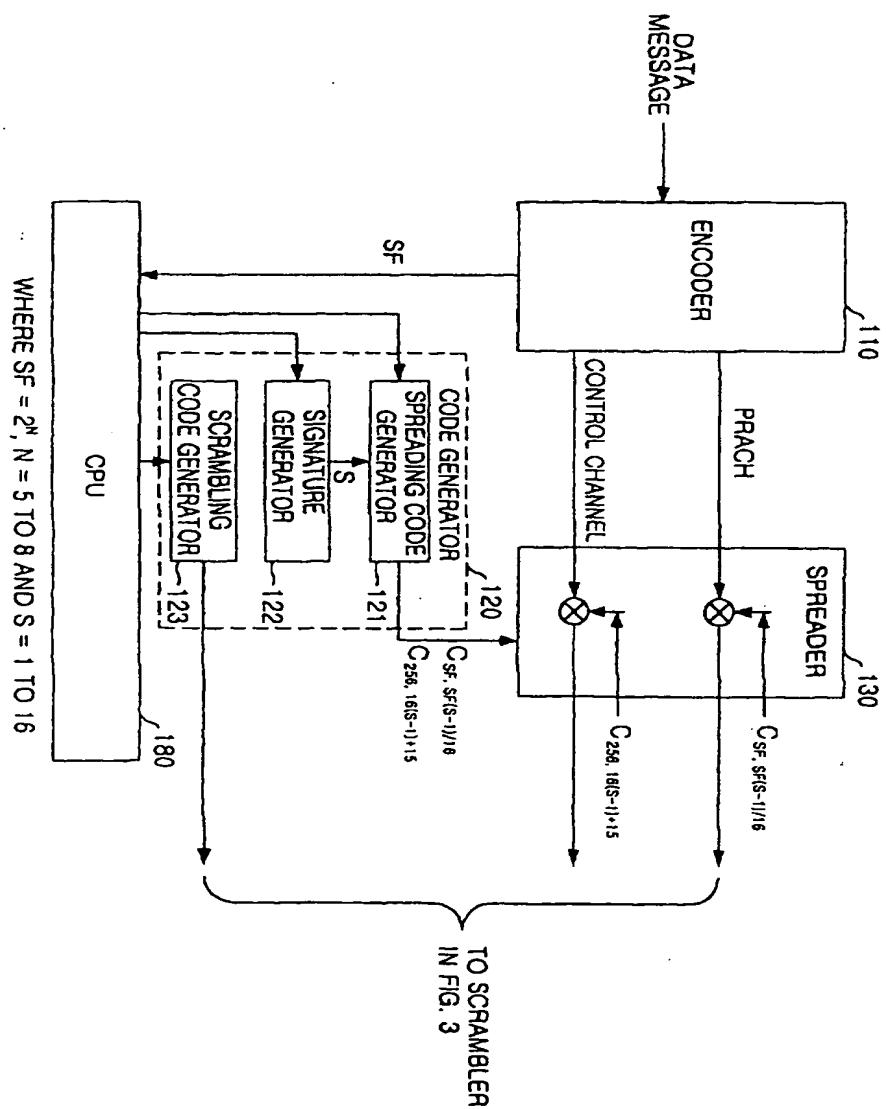
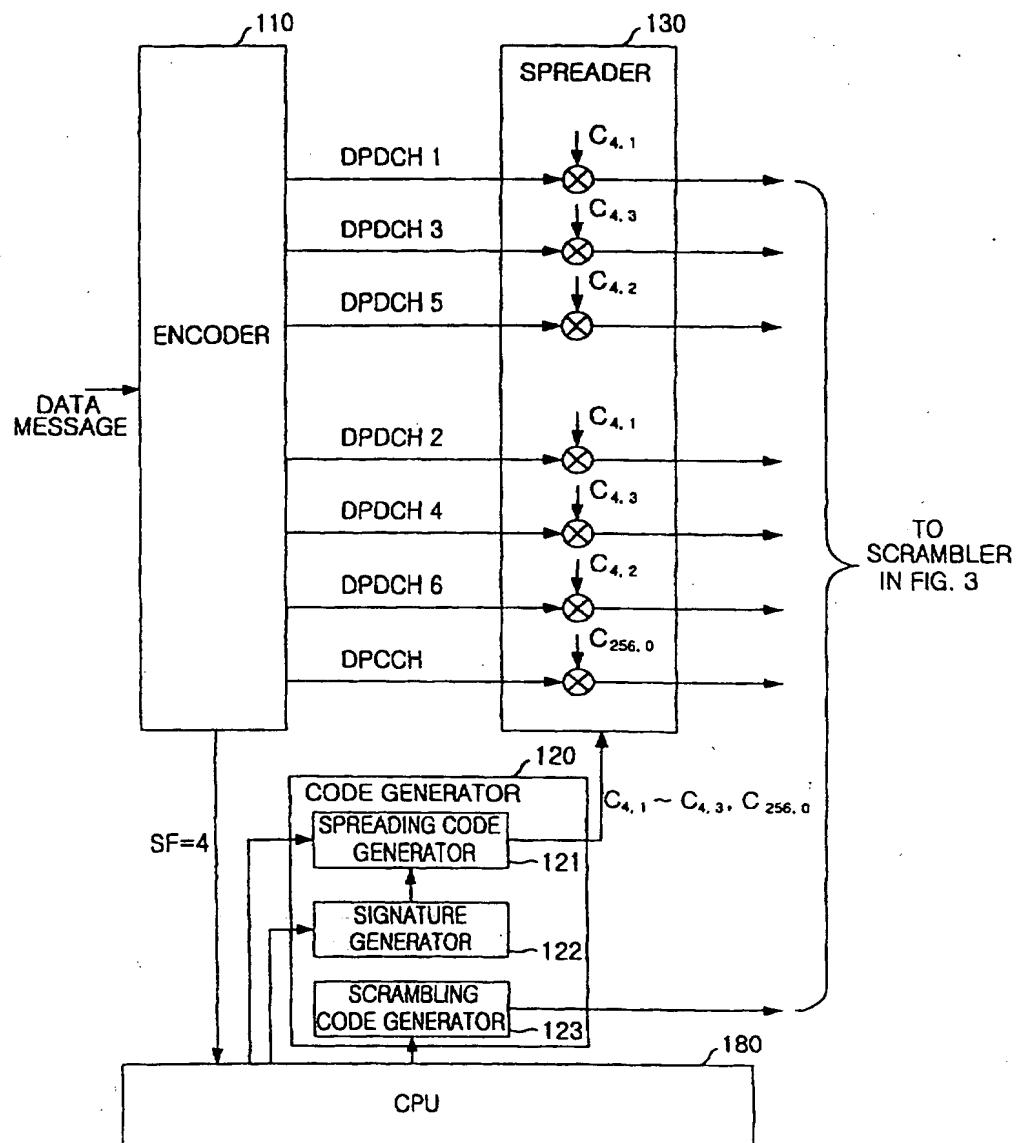


FIG. 6



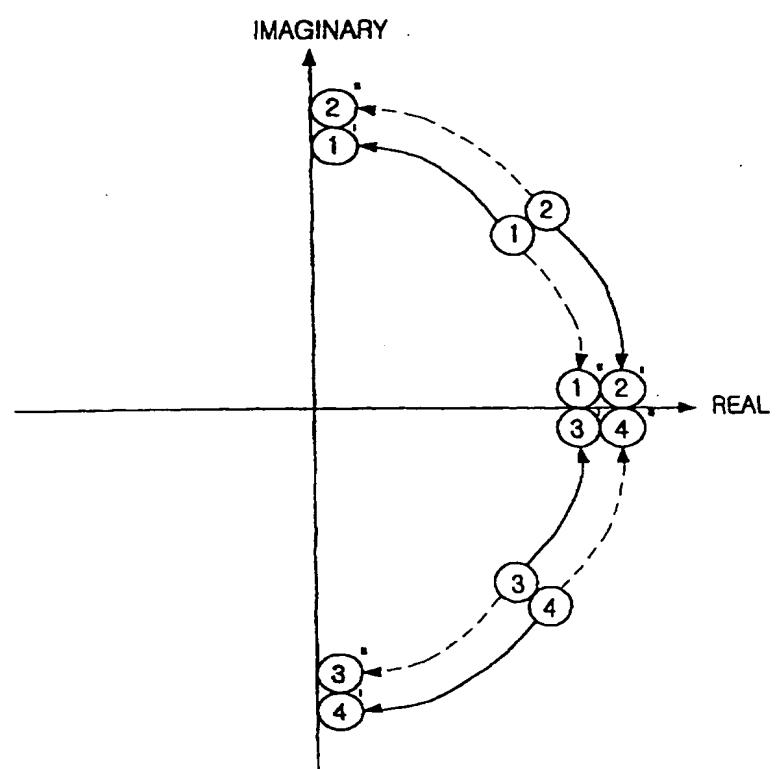
WHERE  $SF = 2^N$ ,  $N = 5$  TO  $8$  AND  $S = 1$  TO  $16$

FIG. 7



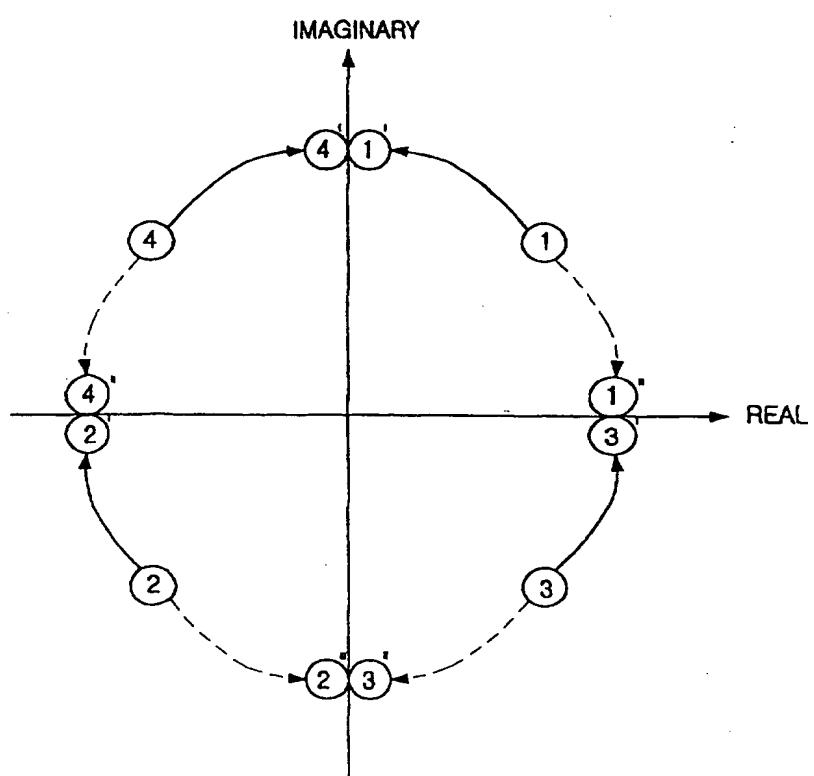
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FIG. 8



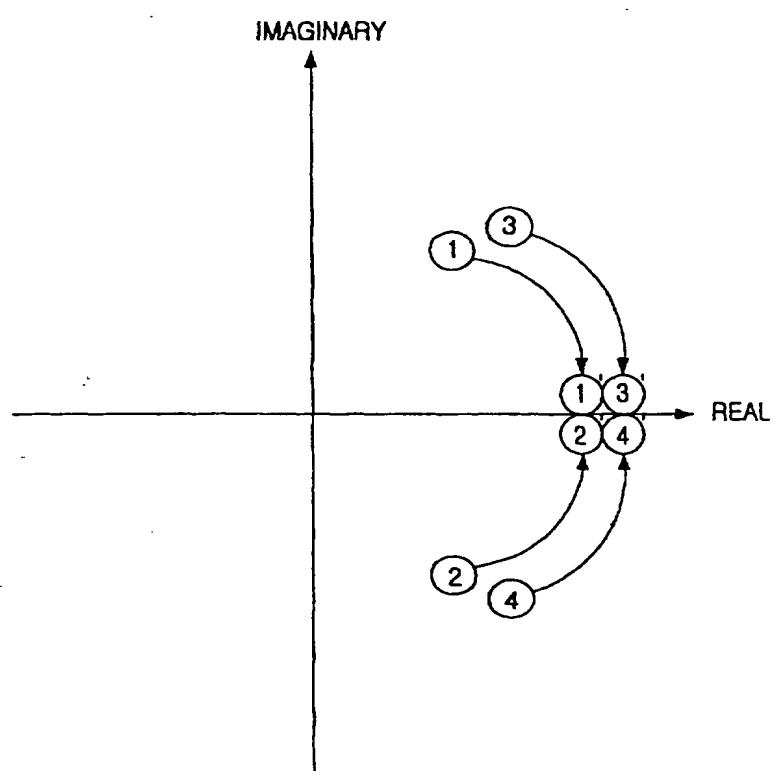
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FIG. 9



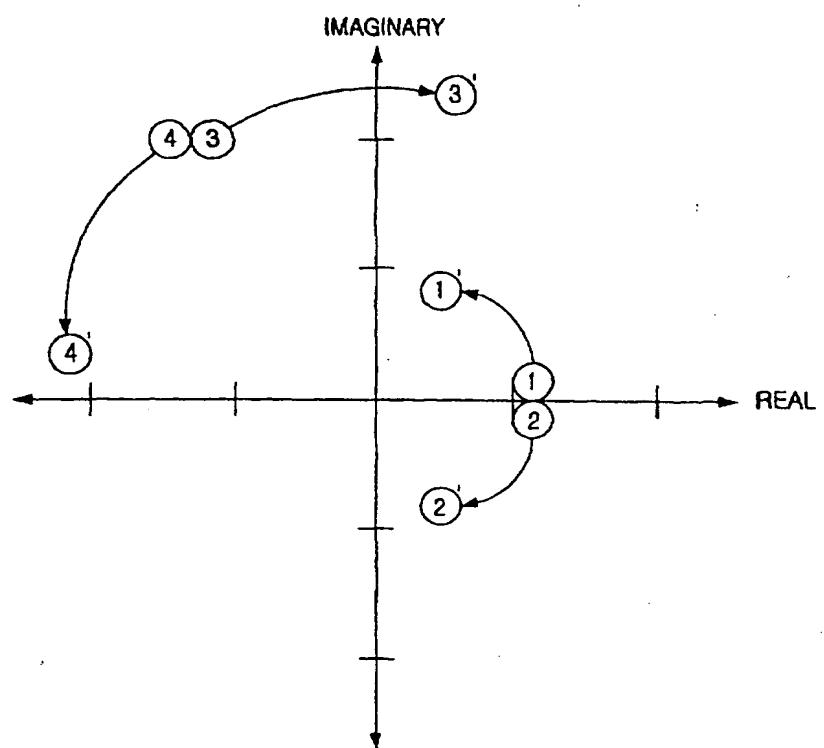
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FIG. 10



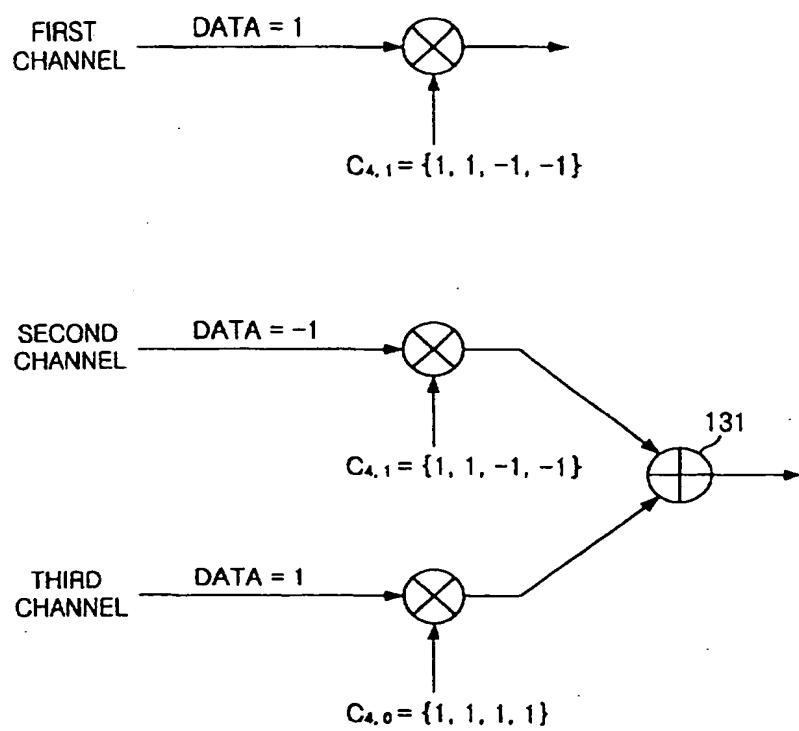
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FIG. 11



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FIG. 12



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FIG. 13

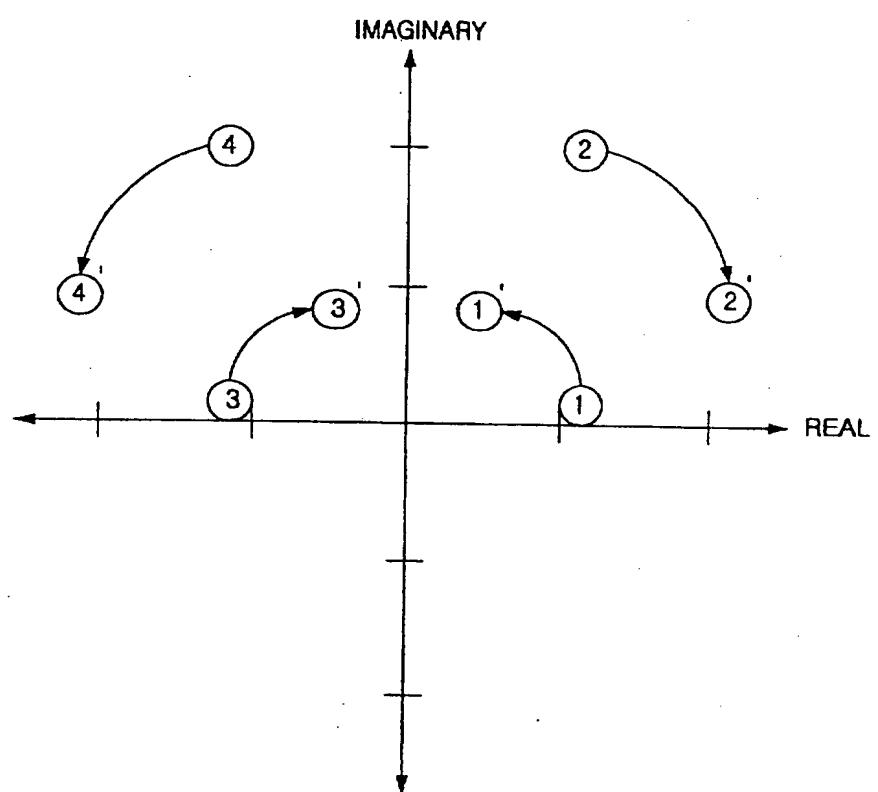
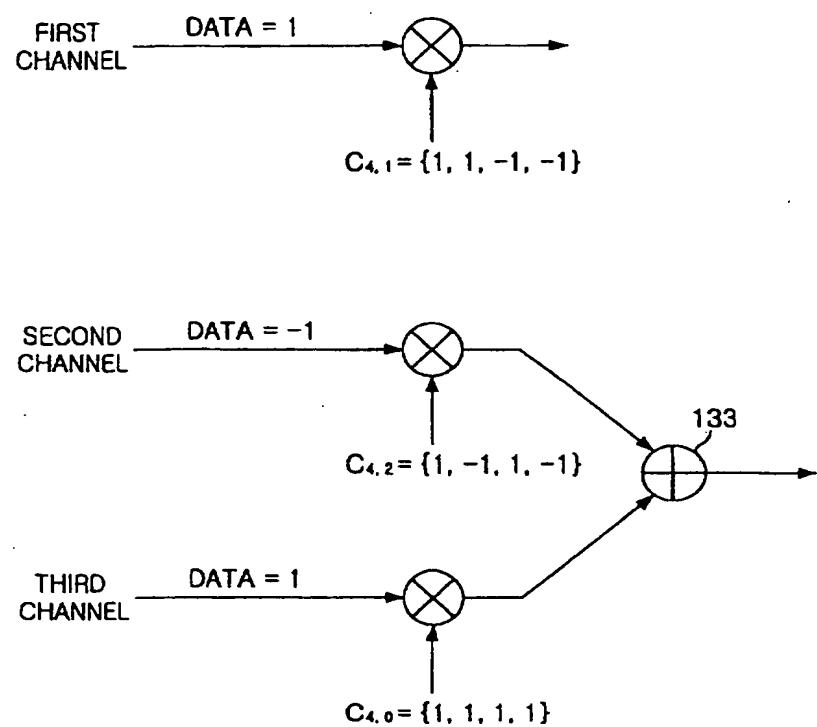


FIG. 14



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FIG. 15

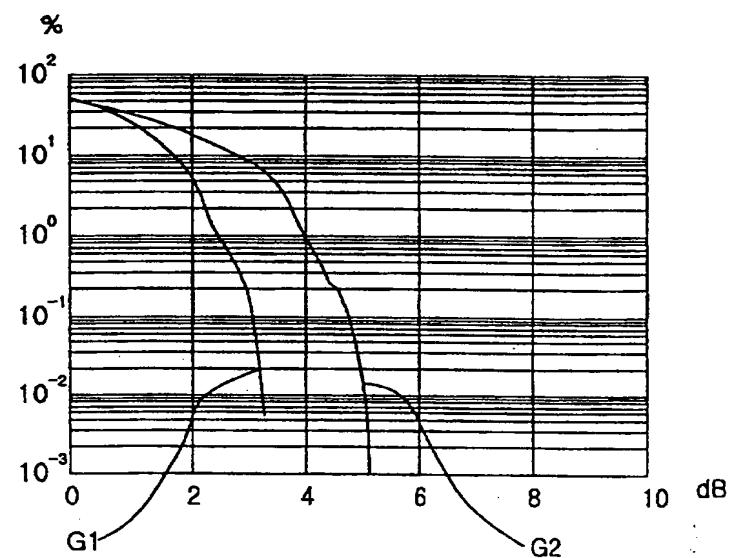
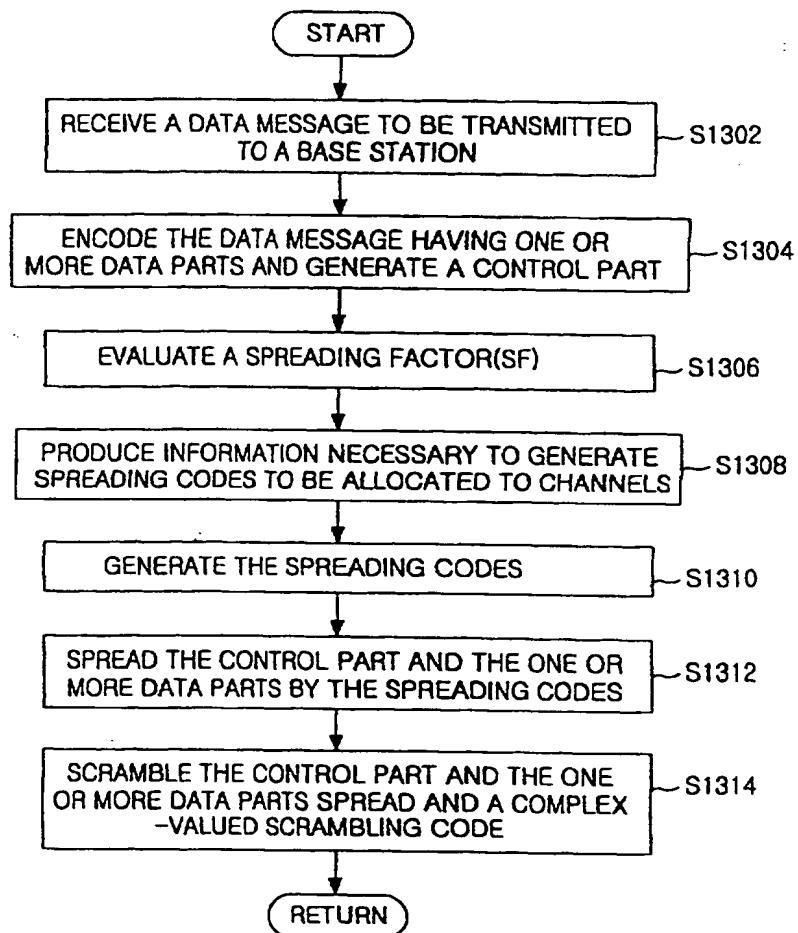


FIG. 16



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FIG. 17

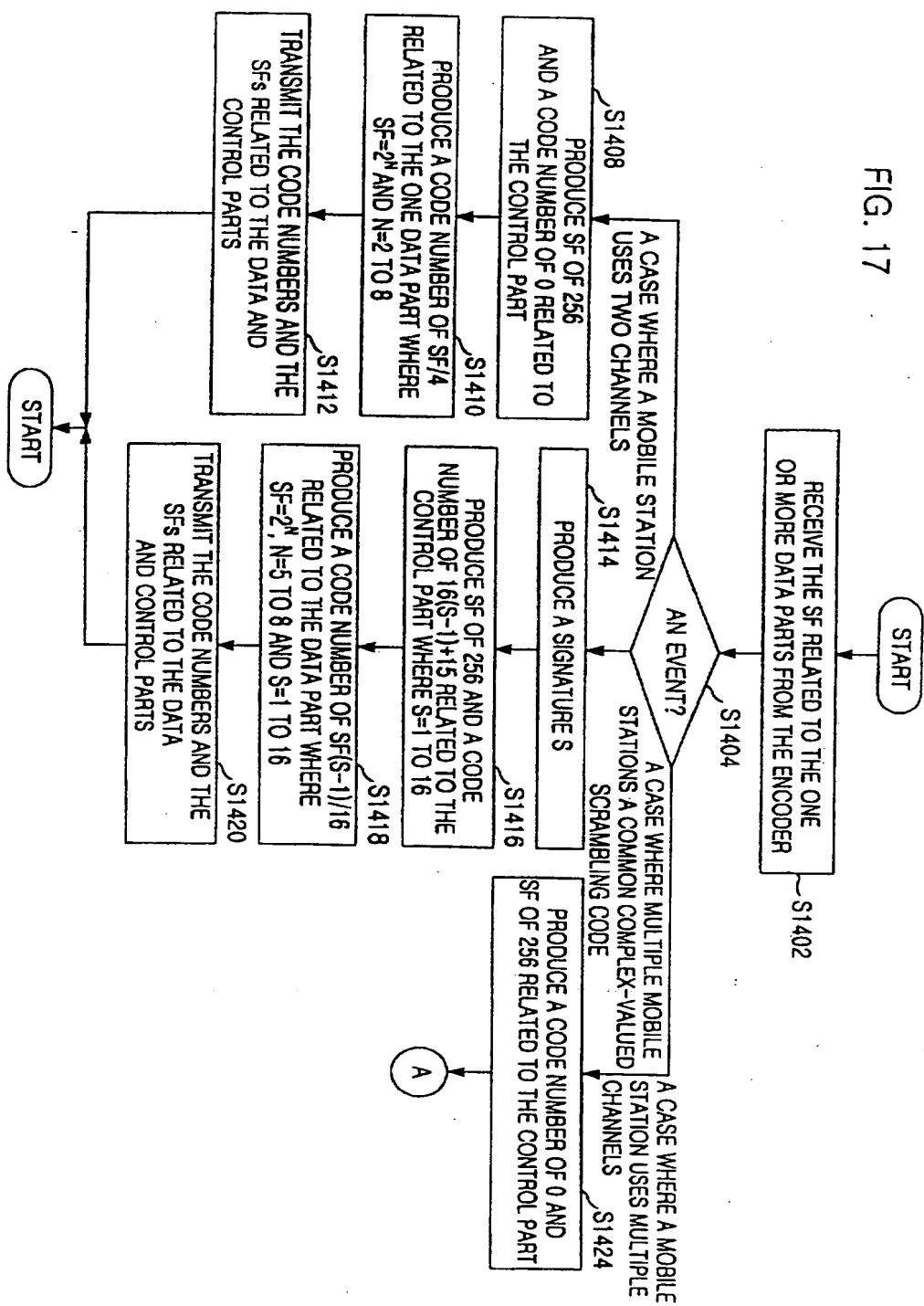


FIG. 18

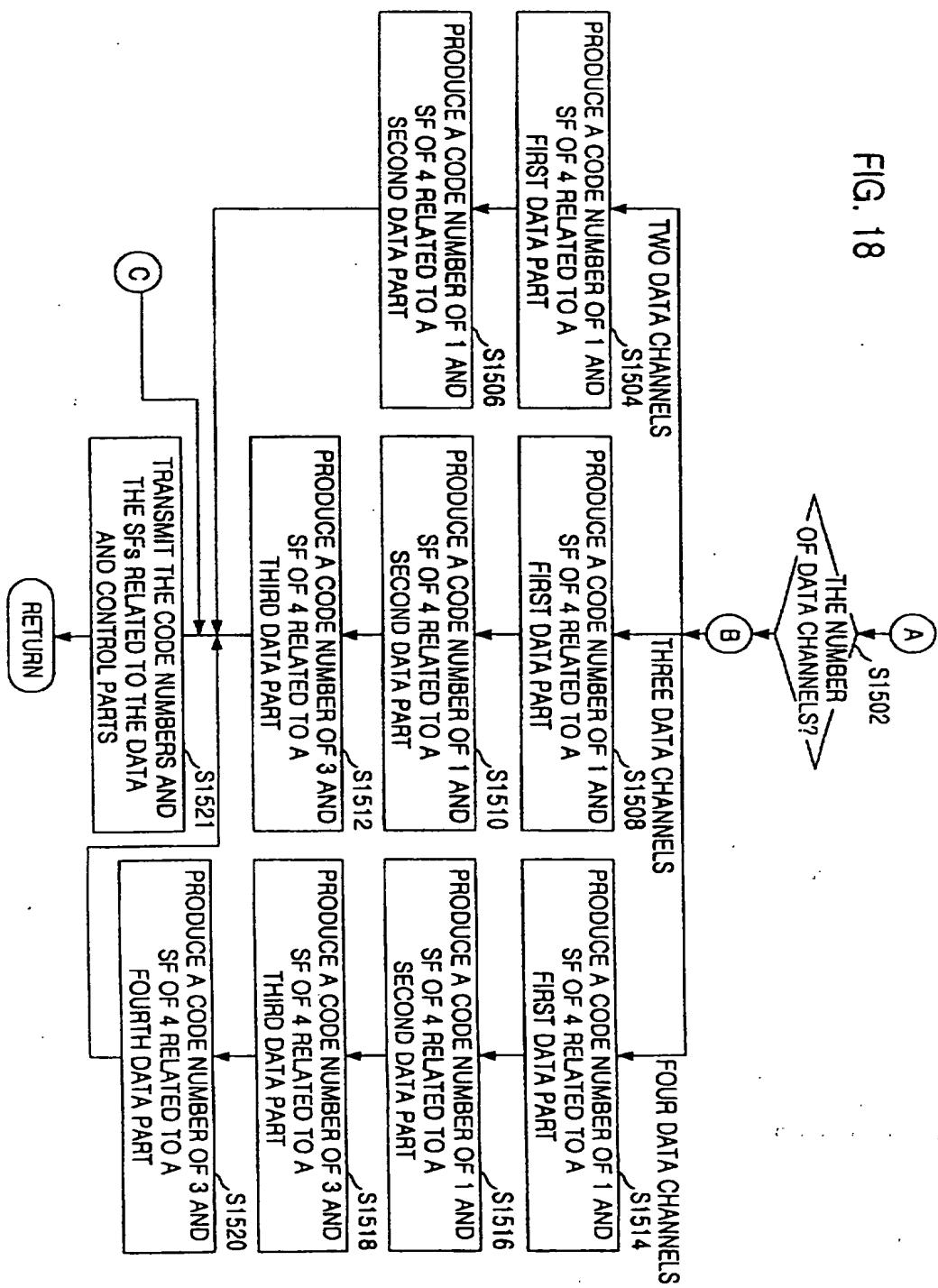


FIG. 19

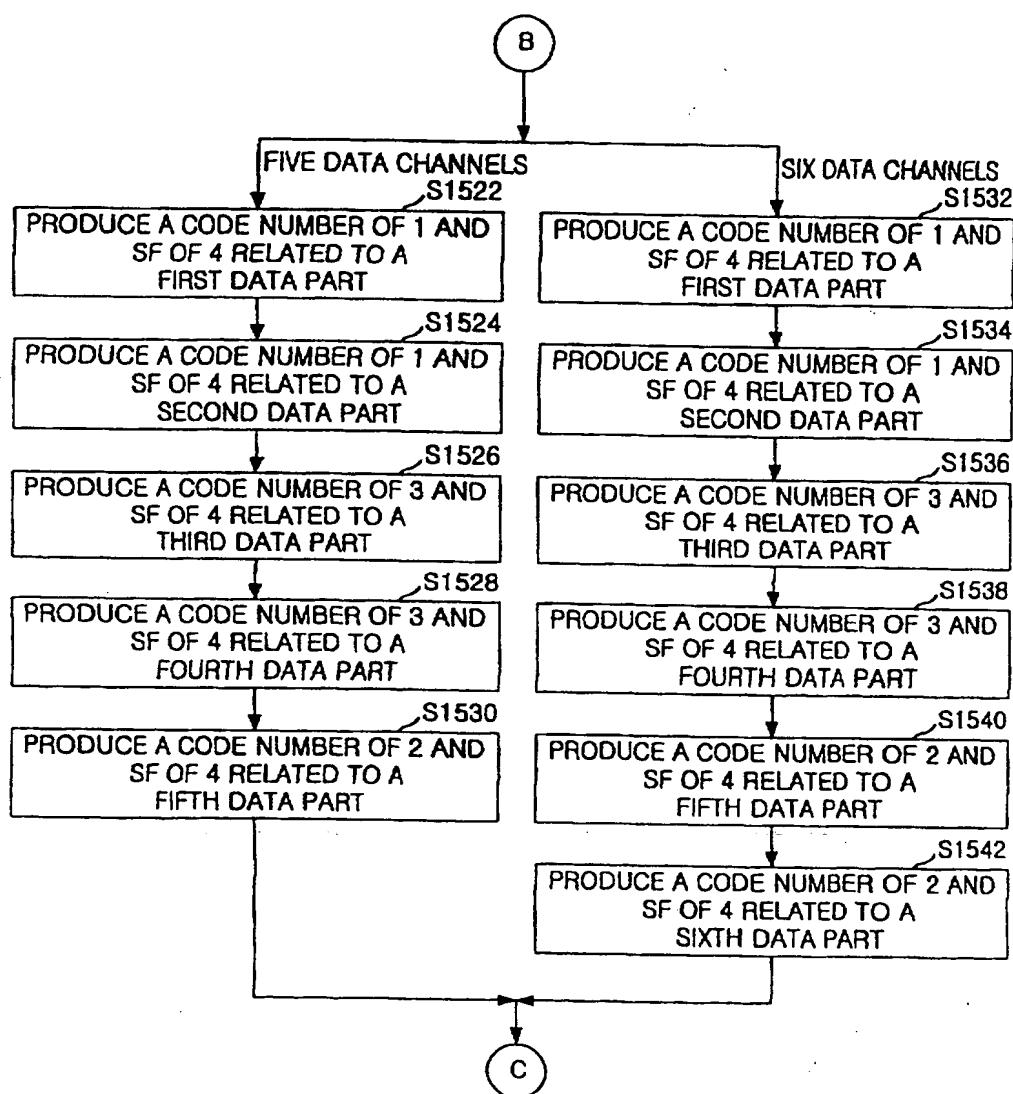


FIG. 20

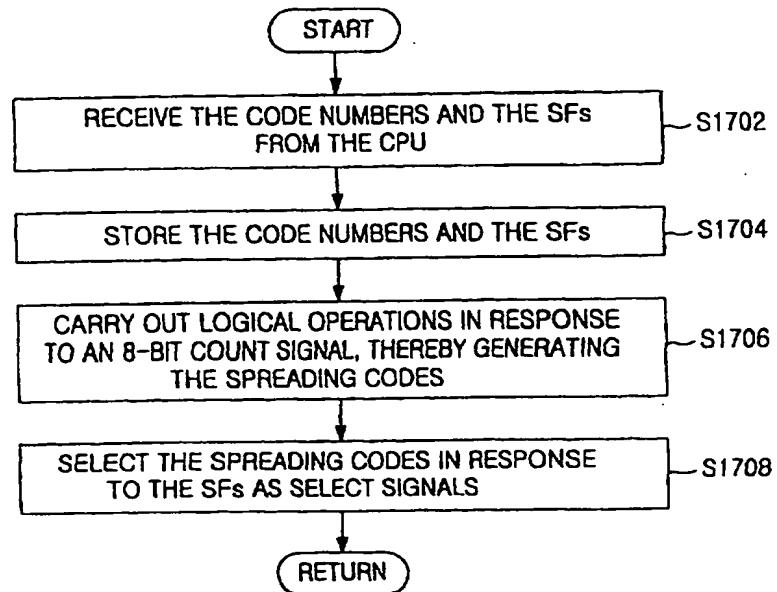


FIG. 21

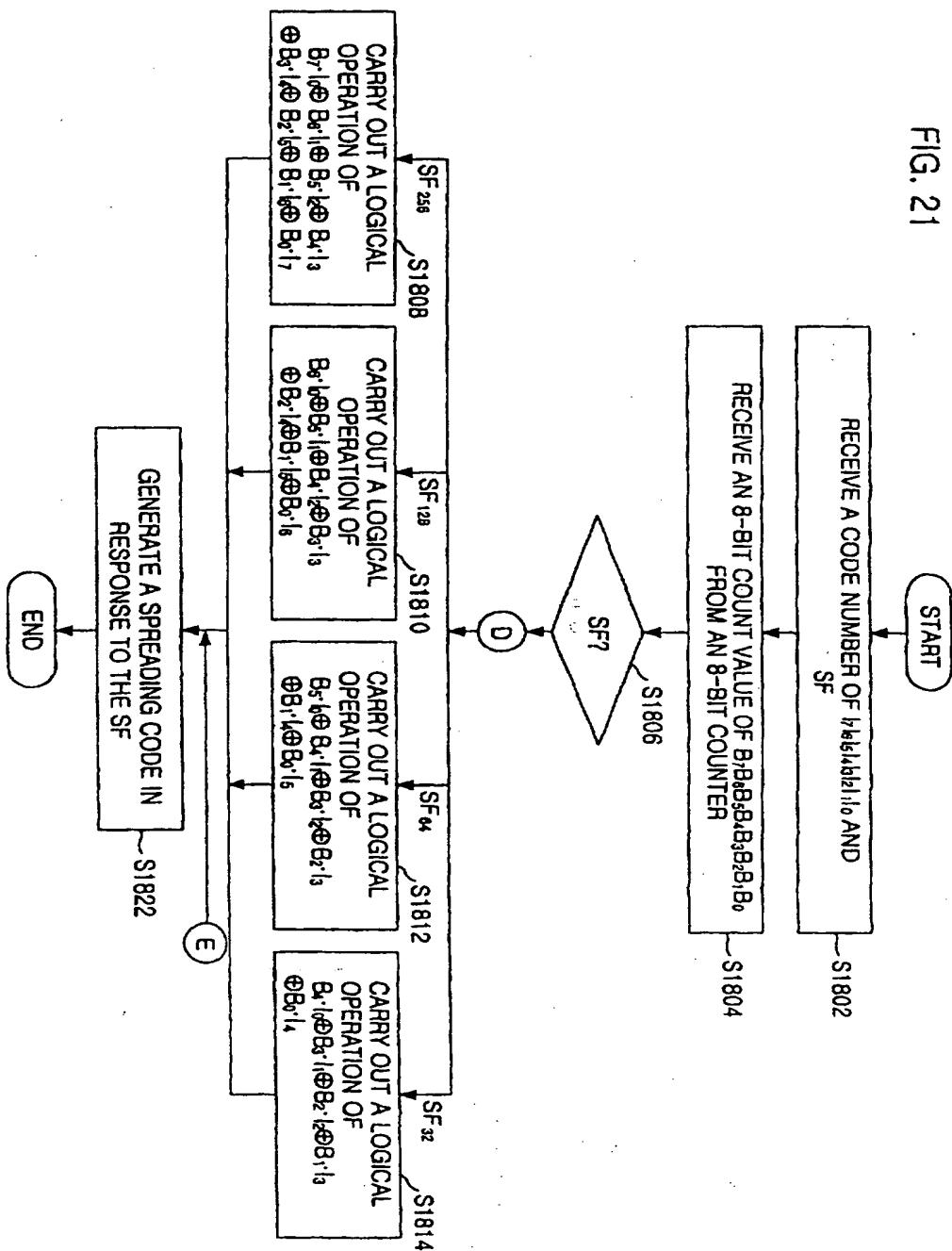
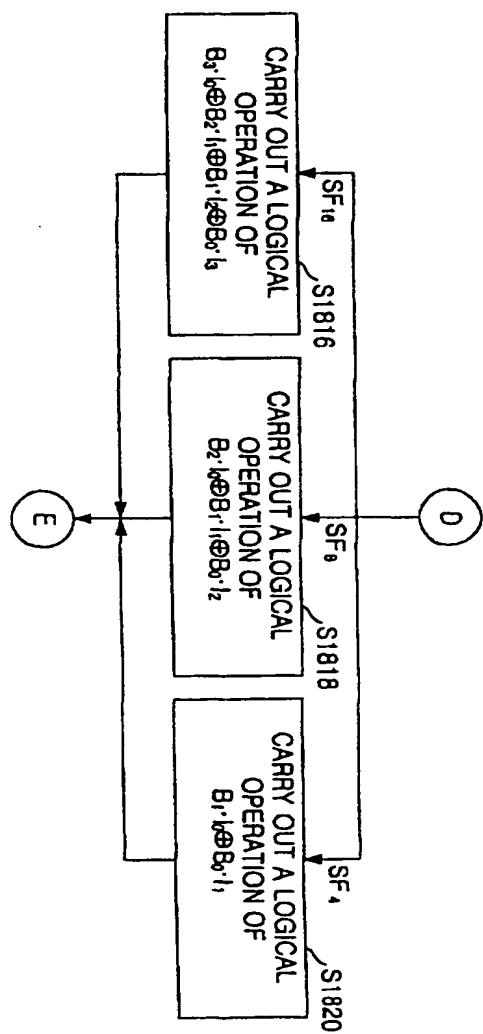


FIG. 22



APPARATUS AND METHOD FOR MODULATING DATA MESSAGE BY EMPLOYING  
ORTHOGONAL VARIABLE SPREADING FACTOR (OVSF) CODES IN MOBILE  
COMMUNICATION SYSTEM

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Field of the Invention

The present invention relates to an apparatus and method for modulating a data message in a mobile communication system; and, more particularly, to an apparatus and method for modulating a data message 10 by employing orthogonal variable spreading factor (OVSF) codes in a mobile communication system.

Description of the Prior Art

15

Generally, a mobile communication system such as an international mobile telecommunication-2000 (IMT-2000) system is capable of providing various services of good quality and large capacity, an international roaming and so on. The mobile communication system can be applicable to high-speed data and 20 multimedia services such as an Internet service and an electronic commerce service. The mobile communication system carries out orthogonal spread with respect to multiple channels. The mobile communication system allocates the orthogonal spread channels to an in-phase (I) branch and a quadrature-phase (Q) branch. A peak- 25 to-average power ratio (PAPR) needed to simultaneously transmit I-branch data and Q-branch data affects power efficiency of a mobile station and a battery usage time of the mobile station.

The power efficiency and the battery usage time of the mobile station are closely related to a modulation scheme of the mobile station. As a modulation standard of IS-2000 and asynchronous wideband-CDMA, the modulation scheme of orthogonal complex quadrature phase shift keying (OCQPSK) has been adopted. The modulation scheme of OCQPSK is disclosed in an article by JaeRyong Shim and SeungChan Bang: 'Spectrally Efficient Modulation and Spreading Scheme for CDMA Systems' in *electronics letters*, 12th November 1998, vol. 34, No. 23, pp. 2210-2211.

As disclosed in the article, the mobile station carries out the orthogonal spread by employing a Hadamard sequence as a Walsh code in the modulation scheme of the OCQPSK. After the orthogonal spread, I and Q channels are spread by a Walsh rotator and a spreading code, e.g., a pseudo noise (PN) code, a Kasami code, a Gold code and so on.

Further, as for multiple channels, the mobile station carries out the orthogonal spread by employing different Hadamard sequences. After the orthogonal spread, the orthogonal spread channels are coupled to I and Q branches. Then, the orthogonal spread channels coupled to the I branch and the orthogonal spread channels coupled to the Q branch are separately summed. The I and Q branches are scrambled by the Walsh rotator and the scrambling code. However, there is a problem that the above-mentioned modulation scheme can not effectively reduce the PAPR in the mobile communication system.

### Summary of the Invention

It is, therefore, an object of the present invention to provide an apparatus and method for modulating a data message that is capable 5 of improving a power efficiency of a mobile station by reducing a peak-to-average power ratio in a mobile communication system.

In accordance with an embodiment of an aspect of the present invention, there is provided an apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase 10 (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising: channel coding means for encoding the source data to generate at least one data part and a control part; code generating means for generating at least one spreading code to be allocated to the channel, wherein each 15 spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control 20 part and the data part by using the spreading code, to thereby generate the channel-modulated signal.

In accordance with another embodiment of the aspect of the present invention, there is provided an apparatus for converting source data to a channel-modulated signal having a plurality of pairs 25 of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, comprising: channel coding means for encoding the

source data to generate  $(N-1)$  number of data parts and a control part; code generating means for generating  $N$  number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part 5 and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control part and the data parts by using the spreading codes, to thereby generate the channel- 10 modulated signal.

In accordance with an embodiment of another aspect of the present invention, there is provided a mobile station for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data, wherein the mobile 15 station uses  $N$  number of channels where  $N$  is a positive integer, comprising: channel coding means for encoding the source data to generate  $(N-1)$  number of data parts and a control part; code generating means for generating  $N$  number of spreading codes to be allocated to the first and the second channels, wherein each spreading 20 code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and spreading means for spreading the control part 25 and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

In accordance with an embodiment of further another aspect of

the present invention, there is provided a method for converting source data to a channel- modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising the 5 steps of: a) encoding the source data to generate at least one data part and a control part; b) generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs 10 of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and c) spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal.

In accordance with another embodiment of further another aspect 15 of the present invention, there is provided a method for converting source data to a channel- modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, comprising: a) encoding the source data to generate 20 (N-1) number of data parts and a control part; b) generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to 25 two points located on same point or symmetrical with respect to a zero point on a phase domain; and c) spreading the control part and the data parts by using the spreading codes, to thereby generate the

channel-modulated signal.

Brief Description of the Drawings

5 The above and other objects and features of the instant invention will become apparent from the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

10 Fig. 1 is a block diagram illustrating a mobile station to which the present invention is applied;

Fig. 2 is an exemplary view illustrating a tree structure of spreading codes applied to the present invention;

Fig. 3 is an exemplary block diagram depicting a modulator shown in Fig. 1 in accordance with the present invention;

15 Fig. 4 is a block diagram describing a spreading code generator shown in Fig. 3;

Fig. 5 is an exemplary diagram illustrating a case where a mobile station uses two channels;

20 Fig. 6 is an exemplary diagram depicting a case where multiple mobile stations share a common complex-valued scrambling code;

Fig. 7 is an exemplary diagram showing a case where a mobile station uses multiple channels;

25 Fig. 8 is a first exemplary view describing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

Fig. 9 is a second exemplary view showing a desirable phase difference between rotated points on a phase domain where a Walsh

rotator rotates points at consecutive chips;

Fig. 10 is a first exemplary view depicting an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

5 Figs. 11 and 12 are third exemplary views illustrating a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

10 Figs. 13 and 14 are second exemplary views illustrating an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips;

Fig. 15 is a graphical diagram describing the probability of peak power to average power; and

15 Figs. 16 to 22 are flowcharts illustrating a method for modulating a data message in a mobile station in accordance with the present invention.

#### Detailed Description of the Invention

Referring to Fig. 1, there is shown a block diagram illustrating 20 a mobile station to which the present invention is applied. As shown, the mobile station includes a user interface 20, a central processing unit (CPU) 180, a modem 12, a source codec 30, a frequency converter 80, a user identification module 50 and an antenna 70. The modem 12 includes a channel codec 13, a modulator 100 and a demodulator 25 120. The channel codec 13 includes an encoder 110 and a decoder 127.

The user interface 20 includes a display, a keypad and so on. The user interface 20, coupled to the CPU 180, generates a data

message in response to a user input from a user. The user interface 20 sends the data message to the CPU 180.

The user identification module 50, coupled to the CPU 180, sends user identification information as a data message to the CPU 180.

5 The source codec 30, coupled to the CPU 180 and the modem 12, encodes source data, e.g., video, voice and so on, to generate the encoded source data as a data message. Then, the source codec 30 sends the encoded source data as the data message to the CPU 180 or the modem 12. Further, the source codec 30 decodes the data message from the 10 CPU 180 or the modem 12 to generate the source data, e.g., video, voice and so on. Then, the source codec 30 sends the source data to the CPU 180.

The encoder 110, contained in the channel codec 13, encodes the data message from the CPU 180 or the source codec 30 to generate one 15 or more data parts. Then, the encoder 110 generates a control part.

The encoder 110 sends the one or more data parts to the modulator 100. The modulator 100 modulates the one or more data parts and the control part to generate I and Q signals as baseband signals. The frequency converter 80 converts the baseband signals to intermediate 20 frequency (IF) signals in response to a conversion control signal from the CPU 180. After converting the baseband signals to the IF signals, the frequency converter 80 converts the IF signals to radio frequency (RF) signals. The frequency converter 80 sends the RF signals to the antenna 70. Further, the frequency converter 80 25 controls a gain of the RF signals. The antenna 70 sends the RF signals to a base station (not shown).

The antenna 70 sends the RF signals from the base station to

the frequency converter 80. The frequency converter 80 converts the RF signals to the IF signals. After converting the RF signals to the IF signals, the frequency converter 80 converts the IF signals to the baseband signals as the I and Q signals. The demodulator 90 5 demodulates the I and Q signals to generate the one or more data parts and the control part. The decoder 127, contained in the channel codec 13, decodes the one or more data parts and the control part to generate the data message. The decoder 127 sends the data message to the CPU 180 or the source codec 30.

10 Referring to Fig. 2, there is shown an exemplary view illustrating a tree structure of spreading codes as orthogonal variable spreading factor (OVSF) codes applied to the present invention. As shown, a spreading code is determined by a spreading factor (SF) and a code number in a code tree, wherein the spreading 15 code is represented by  $C_{SF, \text{code number}}$ .  $C_{SF, \text{code number}}$  is made up of a real-valued sequence. The SF is  $2^N$  where N is 0 to 8, and the code number is 0 to  $2^N - 1$ .

$$\begin{bmatrix} C_{2,0} \\ C_{2,1} \end{bmatrix} = \begin{bmatrix} C_{1,0} & C_{1,0} \\ C_{1,0} & -C_{1,0} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \text{ where } C_{1,0} = 1 \quad \text{Eq. (1)}$$

$$\begin{bmatrix}
 C_{2^{(N-1)}, 0} \\
 C_{2^{(N-1)}, 1} \\
 C_{2^{(N-1)}, 2} \\
 C_{2^{(N-1)}, 3} \\
 \vdots \\
 \cdot \\
 \cdot \\
 C_{2^{(N-1)}, 2^{(N-1)}-2} \\
 C_{2^{(N-1)}, 2^{(N-1)}-1}
 \end{bmatrix}
 =
 \begin{bmatrix}
 C_{2^N, 0} & C_{2^N, 0} \\
 C_{2^N, 0} & -C_{2^N, 0} \\
 C_{2^N, 1} & C_{2^N, 1} \\
 C_{2^N, 1} & -C_{2^N, 1} \\
 \vdots & \vdots \\
 \cdot & \cdot \\
 \cdot & \cdot \\
 C_{2^N, 2^N-1} & C_{2^N, 2^N-1} \\
 C_{2^N, 2^N-1} & -C_{2^N, 2^N-1}
 \end{bmatrix}
 \quad \text{where } N \text{ is 1 to 7} \quad \text{Eq. (2)}$$

For example, a spreading code having an SF of 8 and a code number of 1 is represented by  $C_{8, 1} = \{1, 1, 1, 1, -1, -1, -1, -1\}$  according to Eqs. (1) and (2). In case where the SF is more than 2, the spreading 5 codes are grouped by two groups, including a first group and a second group according to a code number sequence. The first group includes the spreading codes with the SF and code numbers of 0 to  $SF/2-1$  and the second group includes the spreading codes with the SF and code numbers of  $SF/2$  to  $SF-1$ . Therefore, the number of spreading codes 10 contained in the first group is the same as that of spreading codes contained in the second group.

Each spreading code contained in the first or second group is made up of real values. Each spreading code contained in the first or second group can be employed in an OCQPSK modulation scheme. It 15 is preferred that a spreading code, contained in the first group, is selected for the OCQPSK modulation scheme. However, where a spreading code, contained in the second group, is multiplied by another spreading code with a minimum code number, i.e.,  $SF/2$ , contained in the second group, the multiplication of the spreading 20 codes, contained in the second group, becomes the same as a spreading

code contained in the first group. Accordingly, the multiplication of the spreading codes contained in the second group is represented by a spreading code of the first group. As a result, all the spreading codes, i.e., OVSF codes, of the first and second groups are useful 5 for reducing the peak-to-average power ratio (PAPR) of the mobile station.

Referring to Fig. 3, there is shown a block diagram depicting a modulator shown in Fig. 1 in accordance with the present invention. The mobile communication system includes a base station and a mobile 10 station employing a plurality of channels, wherein the mobile station includes the modulator. The channels include a control channel and one or more data channels.

The one or more data channels include a physical random access channel (PRACH), a physical common packet channel (PCPCH) and 15 dedicated physical channel (DPCH). In a PRACH or PCPCH application, a control channel and only one data channel, i.e., PRACH or PCPCH, are coupled between the encoder 110 and the spreader 130. The DPCH includes dedicated physical data channels (DPDCHs). In a DPCH application, a dedicated physical control channel (DPCCH) as a 20 control channel and up to six data channels, i.e., DPDCH 1 to DPDCH 5 are coupled between the encoder 110 and the spreader 130. As shown, a modulator 100 includes an encoder 110, a code generator 120, a spreader 130, a scrambler 140, a filter 150, a gain adjuster 160 and an adder 170.

25 The encoder 110 encodes the data message to be transmitted to the base station to generate one or more data parts. The encoder 110 generates a control part having a control information. The

encoder 110 evaluates an SF based on a data rate of the one or more data parts.

The CPU 180, coupled to the encoder 110, receives the SF related to the one or more data parts from the encoder 110. The CPU 180 5 produces one or more code numbers related to the one or more data parts and an SF and a code number related to the control part.

The code generator 120 includes a spreading code generator 121, a signature generator 122 and a scrambling code generator 123. The code generator 120, coupled to the CPU 180, generates spreading codes, 10 i.e.,  $C_{d1}$  to  $C_{dn}$  and  $C_c$ , a signature S and a complex-valued scrambling code. The spreading code generator 121, coupled to the CPU 180 and the spreader 130, generates the spreading codes in response to the SF and the one or more code numbers related to the one or more data parts and an SF and a code number related to the control part from 15 the CPU 180. The spreading code generator 121 sends the spreading codes to the spreader 130.

The signature generator 122, coupled to the CPU 180 and the spreading code generator 121, generates the signature S to send the signature S to the spreading code generator 121. The scrambling code 20 generator 123 generates the complex-valued scrambling code to send the complex-valued scrambling code to the scrambler 140.

The spreader 130 spreads the control part and the one or more data parts from the encoder 110 by the spreading codes from the code generator 120.

25 The scrambler 140 scrambles the complex-valued scrambling code, the one or more data parts and the control part spread by the spreader 130, thereby generating scrambled signals. The scrambler 140

includes a Walsh rotator, which is typically employed in the OCQPSK modulation scheme. The Walsh rotator rotates the one or more data parts and the control part spread by the spreader 130.

The filter 150, i.e., a root raised cosine (PRC) filter, 5 pulse-shapes the scrambled signals to generate pulse-shaped signals.

The gain adjuster 160 multiplies each of the pulse-shaped signals by the gain of each channel, thereby generating gain-adjusted signals.

The adder 170 sums the gain-adjusted signals related to an I branch or the gain-adjusted signals related to a Q branch, to thereby 10 generate a channel-modulated signal having a plurality of pairs of I and Q data in the mobile station.

Referring to Fig. 4, there is shown a block diagram describing a spreading code generator shown in Fig. 3. As shown, the spreading code generator includes a storage device 210, an 8-bit counter 220, 15 a plurality of logical operators 231 and 233 and a plurality of multiplexers 232 and 234.

The storage device 210 includes one or more registers 211 related to the one or more data parts and a register 212 related to the control part. The one or more registers 211 stores an SF and code numbers 20 related to the one or more data parts sent from the CPU 180 shown in Fig. 3. The register 212 stores an SF and a code number related to the control part sent from the CPU 180.

The 8-bit counter 220 consecutively produces a count value of B<sub>7</sub>B<sub>6</sub>B<sub>5</sub>B<sub>4</sub>B<sub>3</sub>B<sub>2</sub>B<sub>1</sub>B<sub>0</sub> as 8-bit count value in synchronization with a clock 25 signal CHIP\_CLK issued from an external circuit, wherein B<sub>0</sub> to B<sub>7</sub> are made up of a binary value of 0 or 1, respectively.

The one or more logical operators 231 carry out one or more

logical operations with the SF and the code numbers related to the one or more data parts stored in the one or more register 211, thereby generating the spreading codes related to the one or more data parts.

A code number is represented by  $I_0 I_1 I_2 I_3 I_4 I_5 I_6 I_7 I_8 I_9$ , wherein  $I_0$  to  $I_9$  are the binary value of 0 or 1, respectively.

The logical operator 233 carries out a logical operation with the SF and the code number of  $I_0 I_1 I_2 I_3 I_4 I_5 I_6 I_7 I_8 I_9$  related to the control part stored in the register 212, thereby generating a spreading code related to the control part.

$$10 \quad \prod_{i=0}^{N-2} \oplus I_i \cdot B_{N-1-i} \quad \text{where } 2 \leq N \leq 8 \quad \text{Eq. (3)}$$

where " $\cdot$ " denotes a multiplication in modulo 2 and  $\oplus$  denotes an exclusive OR operation. Each logical operator 231 or 233 carries out a logical operation according to Eq. (3) where  $SF = 2^N$ .

If the SF is 256, each logical operator 231 or 233 carries out a logical operation of  $B_7 \cdot I_0 \oplus B_6 \cdot I_1 \oplus B_5 \cdot I_2 \oplus B_4 \cdot I_3 \oplus B_3 \cdot I_4 \oplus B_2 \cdot I_5 \oplus B_1 \cdot I_6 \oplus B_0 \cdot I_7$ .

If the SF is 128, each logical operator 231 or 233 carries out a logical operation of  $B_6 \cdot I_0 \oplus B_5 \cdot I_1 \oplus B_4 \cdot I_2 \oplus B_3 \cdot I_3 \oplus B_2 \cdot I_4 \oplus B_1 \cdot I_5 \oplus B_0 \cdot I_6$ .

If the SF is 64, each logical operator 231 or 233 carries out a logical operation of  $B_5 \cdot I_0 \oplus B_4 \cdot I_1 \oplus B_3 \cdot I_2 \oplus B_2 \cdot I_3 \oplus B_1 \cdot I_4 \oplus B_0 \cdot I_5$ .

If the SF is 32, each logical operator 231 or 233 carries out a logical operation of  $B_4 \cdot I_0 \oplus B_3 \cdot I_1 \oplus B_2 \cdot I_2 \oplus B_1 \cdot I_3 \oplus B_0 \cdot I_4$ .

If the SF is 16, each logical operator 231 or 233 carries out a logical operation of  $B_3 \cdot I_0 \oplus B_2 \cdot I_1 \oplus B_1 \cdot I_2 \oplus B_0 \cdot I_3$ .

If the SF is 8, each logical operator 231 or 233 carries out a logical operation of  $B_2 \cdot I_0 \oplus B_1 \cdot I_1 \oplus B_0 \cdot I_2$ .

If the SF is 4, each logical operator 231 or 233 carries out a logical operation of  $B_1 \cdot I_0 \oplus B_0 \cdot I_1$ .

The one or more multiplexers 232 selectively output the one or more spreading codes from the one or more logical operators 231 in response to one or more select signals as the SF related to the one or more data parts.

The multiplexer 234 selectively outputs the spreading code from the logical operator 233 in response to a select signal as the SF related to the control part.

10 Referring to Fig. 5, there is shown an exemplary diagram illustrating a case where a mobile station uses two channels.

As shown, when the mobile station uses the two channels and  $SF = 2^N$  where  $N = 2$  to 8, the spreading code generator 121 generates a spreading code of  $C_{SF, SF/4}$  to be allocated to the DPDCH or the PCPCH 15 as a data channel. Further, the spreading code generator 121 generates a spreading code of  $C_{256, 0}$  to be allocated to the DPCCH or the control channel. Then, the spreader 130 spreads the DPDCH or the PCPCH by the spreading code of  $C_{SF, SF/4}$ . Further, The spreader 130 spreads the control channel by the spreading code of  $C_{256, 0}$ . At 20 this time, the scrambling code generator 123 generates a complex-valued scrambling code assigned to the mobile station. Further, the complex-valued scrambling code can be temporarily reserved in the mobile station.

25 Referring to Fig. 6, there is shown an exemplary diagram depicting a case where multiple mobile stations share a common complex-valued scrambling code in the PRACH application.

As shown, where the multiple mobile stations share a common

complex-valued scrambling code and  $SF = 2^N$  where  $N = 5$  to  $8$  and  $S = 1$  to  $16$ , the spreading code generator 121 generates a spreading code of  $C_{SF, SF(S-1)/16}$  to be allocated to the PRACH. Further, the spreading code generator 121 generates a spreading code of  $C_{256, 16(S-1)+15}$  to be allocated to the control channel.

Then, the spreader 130 spreads the PRACH by the spreading code of  $C_{SF, SF(S-1)/16}$ . Also, the spreader 130 spreads the control channel by the spreading code of  $C_{256, 16(S-1)+15}$ . At this time, the scrambling code generator 123 generates a common complex-valued scrambling code.

Referring to Fig. 7, there is shown an exemplary diagram showing a case where a mobile station uses multiple channels. As shown, where the mobile station uses one control channel and two data channels and the SF related to the two data channels is 4, the spreading code generator 121 generates a spreading code of  $C_{256, 0}$  to be allocated to the DPCCH. Further, the spreading code generator 121 generates a spreading code of  $C_{4, 1}$  allocated to the DPDCH 1. Furthermore, the spreading code generator 121 generates a spreading code of  $C_{4, 1}$  allocated to the DPDCH 2.

Then, the spreader 130 spreads the DPDCH 1 by the spreading code of  $C_{4, 1}$ . Further, the spreader 130 spreads the DPDCH 2 by the spreading code of  $C_{4, 1}$ . Furthermore, the spreader 130 spreads the DPCCH by the spreading code of  $C_{256, 0}$ . At this time, the scrambling code generator 123 generates a complex-valued scrambling codes assigned to the mobile station.

As shown, where the mobile station uses one control channel and three data channels and the SF related to the three data channels

is 4, the spreading code generator 121 further generates a spreading code of  $C_{4,3}$  to be allocated to the DPDCH 3. Then, the spreader 130 further spreads the DPDCH 3 by the spreading code of  $C_{4,3}$ .

As shown, where the mobile station uses one control channel and 5 four data channels and the SF related to the four data channels is 4, the spreading code generator 121 further generates a spreading code of  $C_{4,4}$  to be allocated to the DPDCH 4. Then, the spreader 130 further spreads the DPDCH 4 by the spreading code of  $C_{4,4}$ .

As shown, where the mobile station uses one control channel and 10 five data channels and the SF related to the five data channels is 4, the spreading code generator 121 further generates a spreading code of  $C_{4,2}$  to be allocated to the DPDCH 5. Then, the spreader 130 further spreads the DPDCH 5 by the spreading code of  $C_{4,2}$ .

As shown, where the two mobile station uses one control channel 15 and six data channels and the SF related to the six data channels is 4, the spreading code generator 121 further generates a spreading code of  $C_{4,2}$  to be allocated to the DPDCH 6. Then, the spreader 130 further spreads the DPDCH 6 by the spreading code of  $C_{4,2}$ .

Referring to Fig. 8, there is shown a first exemplary view 20 describing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

As shown, in case where an SF is 4 and a code number is 0, a spreading code of  $C_{4,0}$  is represented by {1, 1, 1, 1}. Further, in 25 case where the SF is 4 and a code number is 1, a spreading code of  $C_{4,1}$  is represented by {1, 1, -1, -1}.

Assume that two channels are spread by the spreading code of

$C_{4,0} = \{1, 1, 1, 1\}$  and the spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ , respectively. At this time, real values contained in the spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$  are represented by points on a real axis of a phase domain. Further, real values contained in 5 the spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$  are represented by points on an imaginary axis of the phase domain.

At a first or second chip, a point  $\{1, 1\}$ , i.e., a point ① or ②, is designated on the phase domain by first or second real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,1}$ . At a third or fourth 10 chip, a point  $\{1, -1\}$ , i.e., a point ③ or ④, is designated on the phase domain by third or fourth real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,1}$ . The points ① and ② are positioned on the same point as each other. Also, the points ③ and ④ are positioned on the same point as each other. Where the Walsh rotator rotates the 15 points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ② at an odd chip, the point ① or ② is rotated to a clockwise direction by a phase of  $45^\circ$ . Further, where the Walsh rotator rotates the point 20 ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of  $45^\circ$ . After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes  $90^\circ$ . Where the 25 phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes  $90^\circ$ , a peak-to-average power ratio (PAPR) of a mobile station can be reduced.

For another example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to the counterclockwise direction by the phase of 45°. Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point 5 ② or ④ is rotated to the clockwise direction by the phase of 45°. After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①'' and ②'' or the rotated points ③'' and ④'' becomes 90°. Where the phase difference between the rotated points ①'' and 10 ②'' or the rotated points ③'' and ④'' becomes 90°, the peak-to-average power ratio of the mobile station can be reduced.

Referring to Fig. 9, there is shown a second exemplary view showing a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

15 First, assume that two channels are spread by a spreading code of  $C_{4,2} = \{1, -1, 1, -1\}$  and a spreading code of  $C_{4,3} = \{1, -1, -1, 1\}$ , respectively.

At a first chip, a point {1, 1}, i.e., a point ①, is designated on the phase domain by first real values contained in the spreading 20 codes of  $C_{4,2}$  and  $C_{4,3}$ . At a second chip, a point {-1, -1}, i.e., a point ②, is designated on the phase domain by second real values contained in the spreading codes of  $C_{4,2}$  and  $C_{4,3}$ . The points ① and ② are symmetrical with respect to a zero point as a center point on the phase domain.

25 At a third chip, a point {1, -1}, i.e., a point ③, is designated on the phase domain by third real values contained in the spreading codes of  $C_{4,2}$  and  $C_{4,3}$ . At a fourth chip, a point {-1, 1}, i.e., a

point ④, is designated on the phase domain by fourth real values contained in the spreading codes of  $C_{4,2}$  and  $C_{4,3}$ . The points ③ and ④ are symmetrical with respect to the zero point on the phase domain. Where the Walsh rotator rotates the points at chips, the points are 5 rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of  $45^\circ$ . Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a 10 counterclockwise direction by the phase of  $45^\circ$ . After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes  $90^\circ$ . Where the phase difference between the rotated points ①' and ②' or the rotated 15 points ③' and ④' becomes  $90^\circ$ , a peak-to-average power ratio of a mobile station can be reduced.

For another example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to the counterclockwise direction by the phase of  $45^\circ$ . Further, where the 20 Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to the clockwise direction by the phase of  $45^\circ$ . After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①'' and ②'' or the rotated points ③'' and ④'' becomes 25  $90^\circ$ . Where the phase difference between the rotated points ①'' and ②'' or the rotated points ③'' and ④'' becomes  $90^\circ$ , the peak-to-average power ratio of the mobile station can be reduced.

Referring to Fig. 10, there is shown a first exemplary view depicting an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

5 First, assume that two channels are spread by the spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$  and the spreading code of  $C_{4,2} = \{1, -1, 1, -1\}$ , respectively.

At a first chip, a point  $\{1, 1\}$ , i.e., a point ①, is designated on the phase domain by first real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,2}$ . At a second chip, a point  $\{1, -1\}$ , i.e., a point ②, is designated on the phase domain by second real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,2}$ . The points ① and ② are symmetrical with respect to the real axis on the phase domain.

At a third chip, a point  $\{1, 1\}$ , i.e., a point ③, is designated 15 on the phase domain by third real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,2}$ . At a fourth chip, a point  $\{1, -1\}$ , i.e., a point ④, is designated on the phase domain by fourth real values contained in the spreading codes of  $C_{4,0}$  and  $C_{4,2}$ . The points ③ and ④ are symmetrical with respect to the real axis on the phase domain.

20 Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a counterclockwise direction by a phase of  $45^\circ$ . Further, where the Walsh rotator rotates 25 the point ② or ④ at an even chip, the point ② or ④ is rotated to a clockwise direction by the phase of  $45^\circ$ . After rotating the points ① and ② or the points ③ and ④ at the odd and even chips as two

consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes zero. Where the phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' does not become  $90^\circ$ , a peak-to-average power ratio of a 5 mobile station can not be reduced.

Referring to Figs. 11 and 12, there are shown third exemplary views illustrating a desirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

10 First, assume that data of 1 allocated to a first channel is spread by a spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ . Further, assume that data of -1 allocated to a second channel is spread by a spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ . Furthermore, assume that data of 1 allocated to a third channel is spread by a spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$ . 15

In terms of the first channel, the spreader 130 shown in Fig. 3 multiplies the data of 1 by the spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ , thereby generating a code of  $\{1, 1, -1, -1\}$ . Further, in terms of the second channel, the spreader 130 multiplies the data 20 of -1 by the spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ , thereby generating a code of  $\{-1, -1, 1, 1\}$ . Furthermore, in terms of the third channel, the spreader 130 multiplies the data of 1 by the spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$ , thereby generating a code of  $\{1, 1, 1, 1\}$ .

Where the spreader 130 includes an adder 131 shown in Fig. 12, 25 the adder 131 generates a code of  $\{0, 0, 2, 2\}$  by adding the code of  $\{-1, -1, 1, 1\}$  to the code of  $\{1, 1, 1, 1\}$ .

Table 1

Chip	1	2	3	4
First Channel	1	1	-1	-1
Second Channel	-1	-1	1	1
Third Channel	1	1	1	1
Second channel + Third channel	0	0	2	2

Table 1 represents the spreading codes allocated to three channels and a sum of two channels depending upon chips. At a first 5 or second chip, a point  $\{1, 0\}$ , i.e., a point ① or ②, is designated on the phase domain by first or second real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 0, 2, 2\}$ . At a third or fourth chip, a point  $\{-1, 2\}$ , i.e., a point ③ or ④, is designated on the phase domain by third or fourth real values contained in the 10 code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 0, 2, 2\}$ . The points ① and ② are positioned on the same point as each other. Also, the points ③ and ④ are positioned on the same point as each other. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

15 For example, where the Walsh rotator rotates the point ① or ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of  $45^\circ$ . Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a counterclockwise direction by the phase of  $45^\circ$ . After rotating the 20 points ① and ② or the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes  $90^\circ$ . Where the

phase difference between the rotated points ①' and ②' or the rotated points ③' and ④' becomes  $90^\circ$ , a peak-to-average power ratio of a mobile station can be reduced.

Referring to Figs. 13 and 14, there are shown second exemplary views illustrating an undesirable phase difference between rotated points on a phase domain where a Walsh rotator rotates points at consecutive chips.

First, assume that data of 1 allocated to a first channel is spread by a spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ . Further, assume that data of -1 allocated to a second channel is spread by a spreading code of  $C_{4,2} = \{1, -1, 1, -1\}$ . Furthermore, assume that data of 1 allocated to a third channel is spread by a spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$ .

In terms of the first channel, the spreader 130 shown in Fig. 15 multiplies the data of 1 with the spreading code of  $C_{4,1} = \{1, 1, -1, -1\}$ , thereby generating a code of  $\{1, 1, -1, -1\}$ . Further, in terms of the second channel, the spreader 130 multiplies the data of -1 by the spreading code of  $C_{4,2} = \{1, -1, 1, -1\}$ , thereby generating a code of  $\{-1, 1, -1, 1\}$ . Furthermore, in terms of the third channel, the spreader 130 multiplies the data of 1 by the spreading code of  $C_{4,0} = \{1, 1, 1, 1\}$ , thereby generating a code of  $\{1, 1, 1, 1\}$ .

Where the spreader 130 includes an adder 133 shown in Fig. 14, the adder 133 generates a code of  $\{0, 2, 0, 2\}$  by adding the code of  $\{-1, 1, -1, 1\}$  to the code of  $\{1, 1, 1, 1\}$ .

25

Table 2

Chip	1	2	3	4
First Channel	1	1	-1	-1
Second Channel	-1	1	-1	1
Third Channel	1	1	1	1
Second channel + third channel	0	2	0	2

Table 2 represents the spreading codes allocated to three channels and a sum of two channels depending upon chips. At a first chip, a point  $\{1, 0\}$ , i.e., a point ①, is designated on the phase domain by first real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 2, 0, 2\}$ . At a second chip, a point  $\{1, 2\}$ , i.e., a point ②, is designated on the phase domain by second real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 2, 0, 2\}$ . At a third chip, a point  $\{-1, 0\}$ , i.e., a point ③, is designated 5 on the phase domain by third real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 2, 0, 2\}$ . At a fourth chip, a point  $\{-1, 2\}$ , i.e., a point ④, is designated 10 on the phase domain by third real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 2, 0, 2\}$ . At a fourth chip, a point  $\{-1, 2\}$ , i.e., a point ④, is designated 15 on the phase domain by third real values contained in the code of  $\{1, 1, -1, -1\}$  and the code of  $\{0, 2, 0, 2\}$ .

The points ① and ② or the points ③ and ④ are positioned on different points from each other. Where the Walsh rotator rotates the points at chips, the points are rotated by a predetermined phase, respectively.

For example, where the Walsh rotator rotates the point ① or 20 ③ at an odd chip, the point ① or ③ is rotated to a clockwise direction by a phase of  $45^\circ$ . Further, where the Walsh rotator rotates the point ② or ④ at an even chip, the point ② or ④ is rotated to a

counterclockwise direction by the phase of 45°. After rotating the points ③ and ④ at the odd and even chips as two consecutive chips, a phase difference between the rotated points ③' and ④' does not become 90°. Where the phase difference between the rotated points 5 ③' and ④' does not become 90°, a peak-to-average power ratio of a mobile station can increase.

Further, after rotating the points ① and ② at the odd and even chips as two consecutive chips, a phase difference between the rotated points ①' and ②' does not become 90°. Where the phase difference 10 between the rotated points ①' and ②' does not become 90°, the peak-to-average power ratio of a mobile station can increase.

Referring to Fig. 15, there is shown an exemplary graphical diagram describing the probability of peak to average power.

When a mobile station employs two channels and spreading codes 15 of  $C_{4,0} = \{1, 1, 1, 1\}$  and  $C_{4,1} = \{1, 1, -1, -1\}$  allocated to the two channels, a curve G1 is shown in the graphical diagram. At this time, the probability of the peak power exceeding the average power by 2.5 dB is approximately 1%.

Further, when a mobile station employs two channels and 20 spreading codes of  $C_{4,0} = \{1, 1, 1, 1\}$  and  $C_{4,2} = \{1, -1, 1, -1\}$  allocated to the two channels, a curve G2 is shown in the graphical diagram.

At this time, the probability of the peak power exceeding the average power by 2.5 dB is approximately 7%.

Referring to Fig. 16, there is shown a flowchart depicting a 25 method for modulating a data message in a mobile station in accordance with the present invention.

As shown, at step S1302, an encoder receives a data message to

be transmitted to a base station.

At step S1304, the encoder encodes the data message having one or more data parts and generates a control part.

At step S1306, the encoder evaluates an SF related to the one or more data parts to send the SF from an encoder to a CPU.

At step S1308, the CPU produces information necessary to generate spreading codes to be allocated to channels.

At step S1310, a code generator generates the spreading codes.

At step S1312, a spreader spreads the control part and the one or more data parts by the spreading codes.

At step S1314, a scrambler scrambles the control part and the one or more data parts spread and a complex-valued scrambling code, to thereby generate a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in the mobile station.

Referring to Figs. 17 to 19, there are flowcharts illustrative of a procedure for producing information necessary to generate spreading codes to be allocated to channels.

As shown, at step S1402, the CPU receives the SF related to the one or more data parts from the encoder.

At step S1404, the CPU determines a type of an event.

At step S1408, if the event is a case where a mobile station uses two channels, the CPU produces an SF of 256 and a code number of 0 related to the control part.

At step S1410, the CPU produces a code number of SF/4 related to the one data part where  $SF = 2^N$  and  $N = 2$  to 8.

At step S1412, the CPU sends the code numbers and the SFs related

to the data and control parts to the code generator.

On the other hand, at step S1414, if the event is a case where multiple mobile stations share a common complex-valued scrambling code, the CPU produces a signature S.

5 At step S1416, the CPU produces the SF of 256 and a code number of  $16(S-1)+15$  related to the control part where  $S = 1$  to 16.

At step S1418, the CPU produces a code number of  $SF(S-1)/16$  related to the one data part where  $SF = 2^N$ ,  $N = 2$  to 8 and  $S = 1$  to 16.

10 At step S1420, the CPU sends the code numbers and the SFs related to the data and control parts to the code generator.

On the other hand, at step S1424, if the event is a case where a mobile station uses multiple channels, the CPU produces a code number of 0 and the SF of 256 related to the control part allocated 15 to the control channel.

At step S1502, the CPU determines the number of data channels.

At step S1504, if the number of data channels is two data channels, the CPU produces a code number of 1 and an SF of 4 related to a first data part allocated to a first data channel coupled to an I branch.

20 At step S1506, the CPU produces a code number of 1 and the SF of 4 related to a second data part allocated to a second data channel.

On the other hand, at step S1508, if the number of data channels is three data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first 25 data channel.

At step S1510, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data

channel.

At step S1512, the CPU produces a code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

5 On the other hand, at step S1514, if the number of data channels is four data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

10 At step S1516, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

15 At step S1518, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

20 At step S1520, the CPU produces the code number of 3 and the SF of 4 related to a fourth data part allocated to a fourth data channel.

On the other hand, at step S1522, if the number of data channels is five data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

25 At step S1524, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step S1526, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

At step S1528, the CPU produces the code number of 3 and the SF of 4 related to the fourth data part allocated to the fourth data channel.

At step S1530, the CPU produces the code number of 2 and the SF of 4 related to a fifth data part allocated to a fifth data channel.

On the other hand, at step S1532, if the number of data channels is six data channels, the CPU produces the code number of 1 and the SF of 4 related to the first data part allocated to the first data channel.

At step S1534, the CPU produces the code number of 1 and the SF of 4 related to the second data part allocated to the second data channel.

At step S1536, the CPU produces the code number of 3 and the SF of 4 related to the third data part allocated to the third data channel.

At step S1538, the CPU produces the code number of 3 and the SF of 4 related to the fourth data part allocated to the fourth data channel.

At step S1540, the CPU produces the code number of 2 and the SF of 4 related to the fifth data part allocated to the fifth data channel.

At step S1542, the CPU produces the code number of 2 and the SF of 4 related to a sixth data part allocated to a sixth data channel.

At step S1521, the CPU transmits the code numbers and the SFs related to the data and control parts to the code generator.

Referring to Fig. 20, there is shown a flowchart showing a procedure of generating the spreading codes.

As shown, at step S1702, registers receive the code numbers and the SFs from the CPU.

At step S1704, registers store the code numbers and the SFs.

At step S1706, logical operators carry out logical operations 5 in response to an 8-bit count value, thereby generating the spreading codes.

At step S1708, multiplexers select the spreading codes in response to the SFs as select signals.

Referring to Figs. 21 and 22, there are shown flowcharts 10 describing a procedure of carrying out the logical operations in response to the 8-bit count value, thereby generating the spreading codes.

As shown, at step S1802, each register receives a code number of  $I_7I_6I_5I_4I_3I_2I_1I_0$  and a predetermined SF.

15 At step S1804, each register receives an 8-bit count value of  $B_7B_6B_5B_4B_3B_2B_1B_0$  from an 8-bit counter.

At step S1806, a type of the predetermined SF is determined.

At step S1808, if the predetermined SF is  $SF_{256}$ , each logical operator carries out a logical operation of 20  $B_7 \cdot I_0 \oplus B_6 \cdot I_1 \oplus B_5 \cdot I_2 \oplus B_4 \cdot I_3 \oplus B_3 \cdot I_4 \oplus B_2 \cdot I_5 \oplus B_1 \cdot I_6 \oplus B_0 \cdot I_7$ .

At step S1810, if the predetermined SF is  $SF_{128}$ , each logical operator carries out a logical operation of  $B_6 \cdot I_0 \oplus B_5 \cdot I_1 \oplus B_4 \cdot I_2 \oplus B_3 \cdot I_3 \oplus B_2 \cdot I_4 \oplus B_1 \cdot I_5 \oplus B_0 \cdot I_6$ .

At step S1812, if the predetermined SF is  $SF_{64}$ , each logical 25 operator carries out a logical operation of  $B_5 \cdot I_0 \oplus B_4 \cdot I_1 \oplus B_3 \cdot I_2 \oplus B_2 \cdot I_3 \oplus B_1 \cdot I_4 \oplus B_0 \cdot I_5$ .

At step S1814, if the predetermined SF is  $SF_{12}$ , each logical operator carries out a logical operation of  $B_4 \cdot I_0 \oplus B_3 \cdot I_1 \oplus B_2 \cdot I_2 \oplus B_1 \cdot I_3 \oplus B_0 \cdot I_4$ .

At step S1816, if the predetermined SF is  $SF_{16}$ , each logical operator carries out a logical operation of  $B_3 \cdot I_0 \oplus B_2 \cdot I_1 \oplus B_1 \cdot I_2 \oplus B_0 \cdot I_1$ .

At step S1818, if the predetermined SF is  $SF_8$ , each logical operator carries out a logical operation of  $B_2 \cdot I_0 \oplus B_1 \cdot I_1 \oplus B_0 \cdot I_2$ .

At step S1820, if the predetermined SF is  $SF_4$ , each logical operator carries out a logical operation of  $B_1 \cdot I_0 \oplus B_0 \cdot I_1$ .

10 At step S1822, each multiplexer generates a spreading code in response to the SF.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions 15 are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

1. An apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising:
  - channel coding means for encoding the source data to generate at least one data part and a control part;
  - code generating means for generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain;
  - and
- spreading means for spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal.
2. The apparatus as recited in claim 1, wherein said channel coding means includes:
  - spreading factor generation mean for generating a spreading factor related to the data rate of the data part.
3. The apparatus as recited in claim 2, wherein said code generating means includes:
  - control means responsive to the spreading factor, for

generating a code number for the channel; and

spreading code generation means responsive to the spreading factor and the code number, for generating the spreading code to be allocated to the channel.

5

4. The apparatus as recited in claim 3, wherein said control means generates a spreading factor and a code number related to the control part.

10 5. The apparatus as recited in claim 4, wherein said spreading code generation means generates a spreading code related to the control part in response to the spreading factor and the code number related to the control part.

15 6. The apparatus as recited in claim 5, wherein said spreading code generation means includes:

counting means for consecutively producing a count value in synchronization with a clock signal;

20 first logical operation means responsive to the count value for carrying out a logical operation with the spreading factor and the code number related to the data part, to thereby generate the spreading code related to the data part; and

25 second logical operation means responsive to the count value for carrying out a logical operation with related to the control part, to thereby generate the spreading code related to the control part.

7. The apparatus as recited in claim 6, wherein said spreading code generation means further includes:

first selection means for outputting the spreading code related to the data part in response to a select signal as the spreading factor related to the data part; and

second selection means for outputting the spreading code related to the control part in response to a select signal as the spreading factor related to the control part.

10 8. The apparatus as recited in claim 7, wherein each of said first and second logical operation means receives a code number of  $I_7I_6I_5I_4I_3I_2I_1I_0$ , a count value of  $B_7B_6B_5B_4B_3B_2B_1B_0$  and a predetermined spreading factor.

15 9. The apparatus as recited in claim 8, wherein each of first and second logical operation means carries out a logical operation of  $\prod_{i=0}^{N-2} I_i \bullet B_{N-1-i}$  if the predetermined spreading factor is  $2^N$  where N is 2 to 8.

20 10. The apparatus as recited in claim 9, wherein said counting means includes an 8-bit counter when the  $2^N$  is a maximum spreading factor.

11. The apparatus as recited in claim 10, wherein said first  
25 and second logical operation means include a plurality of AND gates and a plurality of exclusive OR gates, respectively.

12. The apparatus as recited in claim 11, wherein said first and second selection means include a multiplexer, respectively.

5 13. The apparatus as recited in claim 11, wherein said spreading means includes multipliers.

14. The apparatus as recited in claim 13, wherein said multipliers include:

10 first multiplier for multiplying the data part by the spreading code related to the data part; and

second multiplier for multiplying the control part by the spreading code related to the control part.

15 15. The apparatus as recited in claim 14, wherein said mobile station includes a data channel and a control channel.

16. The apparatus as recited in claim 15, wherein the spreading factor and the code number related to the control part are 256 and 20 0, respectively and wherein the control part is allocated to the control channel.

17. The apparatus as recited in claim 16, wherein the spreading factor related to the data part is  $2^N$  where  $N = 2$  to 8 and wherein 25 the code number related to the data part is  $2^N/4$  and wherein the data part is allocated to the data channel.

18. The apparatus as recited in claim 15, wherein said code generating means further includes;

signature generation means for generating a predetermined signature; and

5 scrambling code generation means for generating a scrambling code.

19. The apparatus as recited in claim 18, wherein the code numbers related to the data part and the control part are dependent  
10 on the predetermined signature, if the scrambling code is shared by multiple mobile stations and wherein the data part and the control part are allocated to the data channel and the control channel, respectively.

15 20. The apparatus as recited in claim 19, wherein the spreading factor related to the control part is 256 and wherein the code number related to the control part is  $16(S-1)+15$  where  $S = 1$  to 16 and  $S$  is the predetermined signature.

20 21. The apparatus as recited in claim 20, wherein the spreading factor related to the data part is  $2^N$  where  $N = 5$  to 8 and wherein the code number related to the data part is  $2^N(S-1)+15$ .

22. The apparatus as recited in claim 1, wherein the spreading  
25 codes include an orthogonal variable spreading factor (OVSF) code.

23. The apparatus as recited in claim 1, further comprising:

scrambling means for scrambling the data and control parts and a scrambling code, to thereby rotate the two points.

24. The apparatus as recited in claim 23, wherein the two points  
5 includes a first point and a second point.

25. The apparatus as recited in claim 24, wherein the first and second points are rotated to clockwise and counterclockwise directions by a phase of 45°, respectively.

10

26. The apparatus as recited in claim 25, wherein a phase difference between the rotated first and second points is 90°.

27. The apparatus as recited in claim 24, wherein the first and 15 second points are rotated to counterclockwise and clockwise directions by a phase of 45°, respectively.

28. The apparatus as recited in claim 27, wherein a phase difference between the rotated first and second points is 90°.

20

29. An apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, 25 comprising:

channel coding means for encoding the source data to generate (N-1) number of data parts and a control part;

code generating means for generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive 5 pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and

spreading means for spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-10 modulated signal.

30. The apparatus as recited in claim 29, wherein said mobile station includes a control channel and six data channels.

15 31. The apparatus as recited in claim 30, wherein said six data channels include first, second, third, fourth, fifth and sixth data channels.

32. The apparatus as recited in claim 31, wherein the spreading 20 code allocated to the control channel is represented by  $C_{256}$ , made up of 1's.

33. The apparatus as recited in claim 32, wherein the spreading codes allocated to the first and second data channels are represented 25 by  $C_{4,1} = \{1, 1, -1, -1\}$ , respectively.

34. The apparatus as recited in claim 33, wherein the spreading

codes allocated to the third and fourth data channels are represented by  $C_{4,3} = \{1, -1, -1, 1\}$ , respectively.

35. The apparatus as recited in claim 34, wherein the spreading codes allocated to the fifth and sixth data channels are represented by  $C_{4,2} = \{1, -1, 1, -1\}$ , respectively.

36. The apparatus as recited in claim 29, wherein the spreading codes include an orthogonal variable spreading factor (OVSF) code.

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37. The apparatus as recited in claim 29, further comprising: scrambling means for scrambling the data and control parts and a scrambling code, to thereby rotate the two points.

15 38. The apparatus as recited in claim 37, wherein the two points, includes a first point and a second point.

20 39. The apparatus as recited in claim 38, wherein the first and second points are rotated to clockwise and counterclockwise directions by a phase of  $45^\circ$ , respectively.

40. The apparatus as recited in claim 39, wherein a phase difference between the rotated first and second points is  $90^\circ$ .

25 41. The apparatus as recited in claim 38, wherein the first and second points are rotated to counterclockwise and clockwise directions by a phase of  $45^\circ$ , respectively.

42. The apparatus as recited in claim 41, wherein a phase difference between the rotated first and second points is 90°.

5       43. A mobile station for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data, wherein the mobile station uses N number of channels where N is a positive integer, comprising:  
10       channel coding means for encoding the source data to generate (N-1) number of data parts and a control part;  
15       code generating means for generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and  
20       spreading means for spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

44. The mobile station as recited in claim 43, further comprising:

25       central processing unit coupled to said channel coding means;  
user interface means coupled to the central processing unit for receiving a user input data from a user; and  
source data generation means coupled to said channel coding

means for generating the source data.

45. The mobile station as recited in claim 44, further comprising:

5 frequency converting means coupled to said spreading means for converting the channel-modulated signal to a radio frequency signal; and

antenna for sending the radio frequency signal to a base station.

10 46. A method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses at least one channel, comprising the steps of:

15 a) encoding the source data to generate at least one data part and a control part;

b) generating at least one spreading code to be allocated to the channel, wherein each spreading code is selected on the basis of a data rate of the data part and the control part and spreading codes are selected so that two consecutive pairs of the I and Q data 20 are correspondent to two points located on same point or symmetrical with respect to a zero point on a phase domain; and

c) spreading the control part and the data part by using the spreading code, to thereby generate the channel-modulated signal.

25 47. The method as recited in claim 46, wherein said step a) includes the steps of:

a1) encoding the source data to generate the data part and the

control part; and

15 a2) generating a spreading factor related to the data rate of the data part.

5 48. The method as recited in claim 47, wherein said step b) includes the steps of:

b1) generating the spreading code to be allocated to the channel; and

b2) generating a spreading code related to the control part.

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49. The method as recited in claim 48, wherein said step b1) includes the steps of:

b1-a) generating a code number for the channel in response to the spreading factor; and

15 b1-b) generating the spreading code to be allocated to the channel in response to the spreading factor and the code number.

50. The method as recited in claim 49, wherein said step b2) includes the steps of:

20 b2-a) generating a spreading factor and a code number related to the control part; and

b2-b) generating the spreading code related to the control part in response to the spreading factor and the code number related to the control part.

25

51. The method as recited in claim 50, wherein said step b1-b) includes the steps of:

10 b1-b1) producing a count value in synchronization with a clock signal; and

15 b1-b2) carrying out a logical operation with the spreading factor and the code number related to the data part in response to the count value, to thereby generate the spreading code related to the data part.

20 52. The method as recited in claim 51, wherein said step b2-b1) includes the steps of:

25 b2-b1) producing the count value in synchronization with the clock signal; and

30 b2-b2) carrying out the logical operation the spreading factor and the code number related to the control part in response to the count value, to thereby generate the spreading code related to the control part.

35 53. The method as recited in claim 52, wherein the code number and the count value are represented by an 8-bit signal of  $I_7, I_6, I_5, I_4, I_3, I_2, I_1, I_0$  and an 8-bit signal of  $B_7, B_6, B_5, B_4, B_3, B_2, B_1, B_0$ , respectively.

40

45 54. The method as recited in claim 53, wherein the logical operation is accomplished by  $\prod_{i=0}^{N-2} I_i \cdot B_{N-1-i}$  if the spreading factor is  $2^N$  where N is 2 to 8.

50 55. The method as recited in claim 54, wherein the mobile station includes a data channel and a control channel.

56. The method as recited in claim 55, wherein the spreading factor and the code number related to the control part are 256 and 0, respectively and wherein the control part is allocated to the 5 control channel.

57. The method as recited in claim 56, wherein the spreading factor related to the data part is  $2^N$  where  $N = 2$  to 8 and wherein the code number related to the data part is  $2^N/4$  and wherein the data 10 part is allocated to the data channel.

58. The method as recited in claim 55, wherein said step b) further includes the steps of;

15        b3) generating a predetermined signature; and  
              b4) generating a scrambling code.

59. The method as recited in claim 58, wherein the code numbers related to the data part and the control part are dependent on the predetermined signature, if the scrambling code is shared by multiple 20 mobile stations and wherein the data part and the control part are allocated to the data channel and the control channel, respectively.

60. The method as recited in claim 59, wherein the spreading factor related to the control part is 256 and wherein the code number 25 related to the control part is  $16(S-1)+15$  where  $S = 1$  to 16 and S is the predetermined signature.

61. The method as recited in claim 60, wherein the SF related to the data part is  $2^N$  where  $N = 5$  to  $8$  and wherein the code number related to the data part is  $2^N(S-1)+15$ .

5 62. The method as recited in claim 46, wherein the spreading codes include an orthogonal variable spreading factor (OVSF) code.

63. The method as recited in claim 46, further comprising the step of:

10 d) scrambling the data and control parts and a scrambling code, to thereby rotate the two points.

64. The method as recited in claim 63, wherein the two points include a first point and a second point.

15

65. The method as recited in claim 64, wherein the first and second points are rotated to clockwise and counterclockwise directions by a phase of  $45^\circ$ , respectively.

20 66. The method as recited in claim 65, wherein a phase difference between the rotated first and second points is  $90^\circ$ .

67. The method as recited in claim 64, wherein the first and second points are rotated to counterclockwise and clockwise 25 directions by a phase of  $45^\circ$ , respectively.

68. The method as recited in claim 67, wherein a phase difference

between the rotated first and second points is 90°.

69. A method for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, wherein the mobile station uses N number of channels where N is a positive integer, comprising:

- a) encoding the source data to generate (N-1) number of data parts and a control part;
- 10 b) generating N number of spreading codes to be allocated to the channels, wherein each spreading code is selected on the basis of a data rate of each data part and the control part and the spreading codes are selected so that two consecutive pairs of the I and Q data are correspondent to two points located on same point or symmetrical 15 with respect to a zero point on a phase domain; and
- c) spreading the control part and the data parts by using the spreading codes, to thereby generate the channel-modulated signal.

70. The method as recited in claim 69, wherein the mobile station 20 includes a control channel and six data channels.

71. The method as recited in claim 70, wherein said six data channels include first, second, third, fourth, fifth and sixth data channels.

25

72. The method as recited in claim 71, wherein the spreading code allocated to the control channel is represented by  $C_{256}$ , made

up of 1's.

73. The method as recited in claim 72, wherein the spreading codes allocated to the first and second data channels are represented by  $C_{4,1} = \{1, 1, -1, -1\}$ , respectively.

74. The method as recited in claim 73, wherein the spreading codes allocated to the third and fourth data channels are represented by  $C_{4,3} = \{1, -1, -1, 1\}$ , respectively.

10

75. The method as recited in claim 74, wherein the spreading codes allocated to the fifth and sixth data channels are represented by  $C_{4,2} = \{1, -1, 1, -1\}$ , respectively.

15

76. The method as recited in claim 69, wherein the spreading codes include an orthogonal variable spreading factor (OVSF) code.

77. The method as recited in claim 69, further comprising the step of:

20       d) scrambling the data and control parts and a scrambling code, to thereby rotate the two points.

78. The method as recited in claim 77, wherein the two points include a first point and a second point.

25

79. The method as recited in claim 78, wherein the first and second points are rotated to clockwise and counterclockwise

directions by a phase of 45°, respectively.

80. The method as recited in claim 79, wherein a phase difference between the rotated first and second points is 90°.

5

81. The method as recited in claim 78, wherein the first and second points are rotated to counterclockwise and clockwise directions by a phase of 45°, respectively.

10 82. The method as recited in claim 81, wherein a phase difference between the rotated first and second points is 90°.

15 83. Apparatus for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, substantially and herein described with reference to and as illustrated in the accompanying drawings.

20 84. A mobile station for converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data, substantially as herein described with reference to and as illustrated in the accompanying drawings.

85. A method of converting source data to a channel-modulated signal having a plurality of pairs of in-phase (I) and quadrature-phase (Q) data in a mobile station, substantially as herein described with reference to the accompanying drawings.



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Claims searched: 1-85

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Date of search: 1 December 2000

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4P (PDCSL, PAQ)

Int Cl (Ed.7): H04B 1/707; H04J 11/00, 13/02, 13/04; H04L 23/02, 27/34

Other: Online: WPI, EPODOC, JAPIO, INSPEC

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A, P	EP 0921652 A2 (ELEC. & TELECOM. RESEARCH INST.) See p. 3, lines 40-48; p. 8, lines 23-33 & p. 10, line 30 - p. 11, line 8.	
A, P	WO 00/42752 A1 (SONY) See abstract and fig. 3	
A, P	WO 99/59265 A1 (SAMSUNG) See e.g. the abstract and figs 3 & 5	
A, P	WO 99/38337 A2 (MOTOROLA) See e.g. the abstract	
X	Electronic Letters, Vol. 34, No. 23, 12 November 1998 (IEE), Shim & Bang, "Spectrally efficient modulation and spreading scheme for CDMA systems", pages 2210-2211.	1, 29, 43, 46 & 69 at least
X	INSPEC Abstract Accession No. 6468729 and "3 <sup>rd</sup> CDMA International Conference and Exhibition", published 1998, ETRI, pp 101-105, Vol. 2, Bang et al "A spectrally efficient modulation and spreading scheme using orthogonal channelization and rotator" (see abstract)	1, 29, 43, 46 & 69 at least

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